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WHAT AMERICAN ZOÖLOGISTS HAVE DONE FOR EVOLUTION.[1]

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I.

IT would be pleasant indeed if only a lecture or an essay were expected from the presiding officer of the Section; but an address implies a great deal more, and the giver of it is not only expected to be entertaining, where perhaps he never entertained before, but instructive upon grounds upon which, perchance, he has made but partial survey. Among the many questions of sustaining interest, a number of subjects intrude themselves. A general review of the work accomplished since the last meeting of the Association would seem an appropriate subject for discourse. Yet beyond my special studies I feel quite incompetent to scan so broad a field. In this year of Centennial reviews, one might naturally fall into an attempt to sketch the growth of science and the work accomplished within the last hundred years, but that would not only be too vast a field, but would on the whole be unprofitable, since time-boundaries, like the surveyor's lines bordering a State, have no definite existence in Nature. The natural boundaries of oceans and sierras do indeed isolate and impress peculiarities of thought and action upon man, as upon the creatures below him, and for this reason we may with propriety examine the work of our nation in any line of investigation. Never before has the study of animals been raised to so high a dignity as at present. While chemistry could point to its triumphs in the arts, and geology to the revelations of hidden wealth in the rocks, zoölogy was for the most part a mere adjunct to geology, or a means to thwart the

[1] An address delivered at the meeting of the American Association for the Advancement of Science. Read at Buffalo, New York, August, 1876. By Edward S. Morse, Vice-President Biological Section.

ravages of insects. Now, however, it is the pivot on which the doctrine of man's origin hinges. The worlds themselves are too old to study, though the spectroscope reveals the existence of celestial protoplasm as their physical basis. The rocks are too rigid and the time too immense to come within the compass of our minds, but the living facts of evolution are with us to-day in these graceful forms and their constant changes, while the records more or less preserved in past times give us a clew to things hinted at in the earlier changes of present existing forms. It seems, therefore, at the present time, that a review of the work accomplished by American students for the doctrines of natural selection might be acceptable for several reasons, and first among them might be mentioned the fact that thus far no general review of the kind has been made; and, secondly, that with few exceptions all the general works upon the subject are from English or German sources, and filled with the results of work done there oftentimes to the exclusion of work done elsewhere. The oft-repeated examples in support of the derivative theory belong to Europe. The public are familiar with these facts only, and come naturally to believe that these examples alone exist, and from their remoteness do not carry the weight of equally or perhaps more suggestive facts which lie concealed in the technical publications of our own societies. A review of the work accomplished by American students bearing upon the doctrine of descent must of necessity be brief. Even a review of a moiety of the work is beyond the limits of an address of this nature. And for obvious reasons I must needs here restrict it to one branch of biology, namely, zoölogy. For material, the scientific publications of the country have been scanned, and an attempt has been made to bring together the more prominent facts bearing upon natural selection. In this review the zoölogical science of the country presents itself in two distinct periods: The first period, embracing as to time-limits the greatest portion, may be recognized as embracing the lowest stages of the science; it included among others a class of men who busied themselves in taking an inventory of the animals of the country, an important and necessary work to be compared to that of the hewers and diggers who first settle a new country, but in their work demanding no deep knowledge or breadth of view. And so the work to be done in tabulating the animals has more often been done by specialists who neither knew nor cared to know the facts lying beyond the limits of their studies; a work often prompted by the same spirit that one sees among children in the collection of birds'-eggs and postage-stamps. The workers in this class were compared by Agassiz to those who make the brick and shape the stone for the edifice, an indispensable work, but with it was raised not the edifice but an almost insuperable barrier against the acceptance of views more in accordance with reason and common-sense. So thoroughly interwoven with this work were certain conceptions believed to be infallible, that overpowering

indeed has been the argument to render as coadjutors the very men who so thoroughly opposed Darwin at the outset. It seems unnecessary to point out the mode of work adopted by the class above described. Their honor involved as soon as their name had been attached to a supposed new species, and any deviation from the type oftentimes persistently overlooked, what wonder, when every local variety received a new name and that name stamped upon a supposed valid creation—what wonder, I repeat, that whole groups of animals have been so thoroughly scourged by such work that few have the courage to engage in the task of revision?

Emerson's reflections on the science of England in 1847 would apply with far more propriety to our country even at a much later date, where in his words "one hermit finds this fact and another finds that, and lives and dies ignorant of its value." With the noble examples of Dana, Wyman, Leidy, and Burnett, before them, they did not profit. In fact, the labors of these honored men, and early in the century Lesueur and others, gave the country its largest claim to recognition abroad. The second period dates from the advent of Agassiz in this country. With his presence a gradual but entire change took place. He rendered the study a dignity rather than a pastime. No longer were the triflers to fling their loose work before the academies unrebuked. The protests he uttered in this Association were the means of elevating the tone of the communications. In fact, nothing indicates the poverty of our attainments in zoölogy more than an examination of the volumes preceding Agassiz's presence and the succeeding volumes. With his honest repudiation of all that was bad, he frightened away the lighter chaff, and there was but little solid work left to take its place. Agassiz made men, and his example, and the methods of work taught by him, spread to other parts of the country. He brought the American student into intimate acquaintance with the classical work of European naturalists. In his public lectures the names of Cuvier, Von Baer, Leuckart, and others, became familiar. The public caught the enthusiasm of this great teacher, and money was lavishly given by the citizens and the State in aid of his scientific undertakings. Agassiz's earnest protest against evolution checked the too hasty acceptance of this theory among American students. But even the weight of his powerful opposition could not long retard the gradual spread of Darwin's views; and now his own students, last to yield, have, with hardly an exception, adopted the general view of derivation as opposed to that of special creation. The results of his protest have been beneficial in one sense. They have prompted the seeking of proofs in this country, and now our students are prepared to show the results of their work in evidence of the laws of progressive development, and it is mainly this work that I wish to review. So much is claimed for birthplace that, in the way of history, it may not be amiss to call attention to

the fact that the first clear premonition of the theory of natural selection came from this country.

William Charles Wells, born in this country, at Charleston, South Carolina, in 1757, in a paper read before the Royal Society, in 1813, first substantially originated the theory to account for the black skin of the negro. He limits his application to races of men and certain peculiarities of color, correlated with an immunity from certain diseases; in proof of it he cites domesticated animals, and the selection by man in precisely the same line of argument urged by Darwin. In the preface to the last edition to the "Origin of Species," Darwin refers to Wells's essay as entitled to the credit of containing the earliest known recognition of the principle. Dr. Wells first shows that varieties among men as among animals are always occurring, and having cited the way in which man selects certain qualities among domesticated animals and thus secures different breeds, calls attention to the well-known fact that the black as well as the white races are differently affected by certain diseases of the countries which they inhabit. He finds a coincidence between the immunity from certain diseases and the black color of the skin, though why this is so he does not attempt to explain. He thinks that, through the successive survival of dark skins, the dark variety of the human race has become fixed. Referring to the man's selective action regarding domesticated animals, he says: "But what is here done by art seems to be done with equal efficacy, though more slowly, by Nature, in the formation of varieties of mankind fitted for the country which they inhabit." These sentences have such a Darwinian sound that, when we remember they were dragged from obscurity by Mr. Darwin himself, we can share in what a recent writer[1] happily calls "Mr. Darwin's evident delight at discovering that some one else had said his good things before him, or has been on the verge of uttering them." As early as 1843, Prof. Haldeman[2] discussed some of the arguments brought forward by the opponents of the Lamarckian theory, and offered certain views in favor of the transmutation of species. While he does not hint at the laws of natural selection, he recognizes fully the value of varieties and their persistency and ultimate divergence. He says, "Although we may not be able artificially to produce a change beyond a given point, it would be a hasty inference to suppose that a physical agent acting gradually for ages could not carry the variation a step or two farther, so that instead of the original one we will say four varieties, they might amount to six, the sixth being sufficiently unlike the earlier ones to induce a naturalist to consider it distinct."

In the year 1850, Dr. Joseph Leidy, in a paper on entophyta in living animals, wrote as follows: "The essential conditions of life are

[1] Gray's "Darwiniana," p. 284.

[2] *Journal of the Boston Society of Natural History*, vol. iv., p. 368.

five in number, namely: a germ, nutritive matter, air, water, heat, the four latter undoubtedly existing in the interior of all animals." [1] Dr. Leidy affirms his belief that very slight modifications of these essential conditions of life were sufficient to produce the vast variety of living beings upon the globe. The theory of derivation based upon the principles of natural selection demands the following admissions: that species vary, that peculiarities are transmitted or inherited, that a greater number of individuals perish than survive, and that the physical features of the earth are now and have been constantly changing, and that precisely the same conditions never recur. These are admitted facts. Now comes the theoretical part of natural selection, namely, that the varieties which survive are those which are more in harmony with the environments of the time. These propositions, with minor ones, form the theory of Darwin. Lamarck and others had recognized the gradual enhancement of varieties into species, but had not struck the key-note of natural selection, though Wells in the beginning of the century had clearly recognized it in a pertinent example. If we look impartially at these propositions, we need no demonstration to prove the inheritance of characters the most minute, and even the perpetuation of the most subtile features.

On general principles, too, the proposition, that those individuals best adapted to their surroundings survive, need only be stated to be accepted by a reasonable mind. In truth, to deny it would be to deny, as Alphonse de Candolle says, that a round stone would roll down-hill faster and farther than a flat one. Indeed, this eminent botanist affirms that natural selection is neither a theory nor an hypothesis, but the explanation of a necessary fact. The constant physical changes in the past and present condition of the world are incontrovertibly established. It seems, then, that the prime question resolves itself into whether each species as a whole has something inherent which prompts it to vary irrespective of its environments, or whether a correlation can be established between the variation of species and certain physical conditions inducing these variations, and here let me add that of all groups of animals from species through genera to higher divisions, that group of individuals recognized as a species has the most tangible existence. And, as a proof of this, there need only be mentioned the fact that many naturalists, while regarding species as clearly distinct, have on the other hand looked upon classification as an artificial method to facilitate the study, and hence the innumerable schemes and the successive interpolation of subclasses, sub-orders, sub-families, and sub-genera, which simply circumscribed smaller proofs than had before been recognized.

The rapid multiplication of some of these groups has already formed a serious obstacle to the study of systematic zoölogy.

What would good Dr. Mitchell have said if he could have foreseen

[1] "Proceedings of the Philosophical Academy," vol. iii., p. 7.

the generic lists of to-day! In an article on the "Proteus of Lake Erie," he expressed his aversion to multiplying names in zoölogy, and lamented the tendency. He protested as follows, fifty years ago: "By some, these innovations have been so wantonly introduced, as almost to threaten in the end the erection of every species into a distinct genus."[1] Though these words were undoubtedly aimed at Rafinesque, they were none the less prophetic. Whatever may be said of the existence in nature of other groups, there can be no question that species have the most definite existence, and it would seem then that nothing more need be proved for the theory of descent as opposed to the theory of special creation, than the establishment of the fact that species assume the characters of new species, or disappear altogether with a change of surroundings. As examples might be cited, the transplanting of Alpine seeds to warmer regions below, and an accompanying change of the plant into another species before known in the warmer region, or, more remarkable still, the change of a species of *Crustacean* which lives in salt water, to another species with a partial freshening of the water, and this freshening slowly persisted in, the form changing into another genus, and in so doing losing one of its segments. In the first case we see the effect of temperature, and in the second case the physical influence of salt and water in different proportions.

Now, these and hundreds of similar examples can be incontestably proved.

Even the prolonged existence of the form of some animals, like *Lingula*, may be referred to an inherent vitality which enables them to survive changes that caused the death of thousands of others.

In an early discussion of Darwin's theory,[2] Prof. Agassiz cited the persistence of *Lingula* as fatal to the theory, and Prof. William B. Rogers replied that the vital characters of some animals would enable them to survive above others. Ten years later, I had an opportunity of studying living *Lingula* on the coast of North Carolina, and brought specimens home alive in a small jar of water, and kept them in a common bowl for six months without the slightest care. Their power of surviving under changed conditions—their vitality, in other words—seems incredible.[3] (For further details, *see* reference below.)

It has for a long time been suspected that the species of *Mollusca*, described in such profusion in this country, would be reduced when the slightest attention to their habits had been made. Dr. James Lewis[4] long ago observed that a certain species of fresh-water mussel, described as *Alasmodonta truncata*, is only the truncate form of another species, *A. marginata*. From a careful study of the condi-

[1] *American Journal of Science and Arts*, vol. vii., 1829.

[2] "Proceedings of the Boston Society of Natural History," vol. vii., p. 231, December 15, 1860.

[3] Ibid., vol. xv., p. 315.

[4] Ibid., vol. v., p. 121.

tions surrounding the first form in the Mohawk River, he had reason to believe that the rapid currents which pass over it bear along substances that, coming in contact with the exposed edges of the shell, break them down, thus retarding the growth of the shell at this point, and the animal concentrates its growth-powers to the repairs of the broken portion. The same gentleman also shows that the so-called species *Lymnæa elodes*, *catascopium*, and *marginata*, "are modifications of one type or species, influenced by locality and temperature varying the method of development."[1]

A. G. Wetherby[2] calls attention to the variation in form of a group of fresh-water snails, found in the greatest abundance in certain streams of Tennessee and North Alabama. In showing the varied influences they are subjected to he cites the rapid currents of the channels, and the greater liability of the snails being torn from the rocks. He shows that they are exposed in various ways to the effects of these currents, with all their changing impetus of high and low water—exposed also to privation of food from the scouring sand removing the confervæ, upon which they subsist, from the rocks. He takes into account temperature, chemical action, and the like, and says, "No greater vicissitude can be imagined than this growth in an unstable element." Coincident with these diverse conditions he finds an enormous variety of forms, and frankly acknowledges that many of those described as distinct species must be reduced to synonyms.

George W. Tryon, in his large work on the American Melanians, published by the Smithsonian Institution, having finished his manuscript in 1865, says, under date of 1873, when the work was finally published, "A more enlarged acquaintance with fresh-water shells convinces me that a much greater reduction of the number of species than I have attempted must eventually be made."

If we now look upon the definition of a species, as given by a gentleman foremost in the ranks as a describer of species, we find it formulated as follows: A species represents "a primary established law, stamped with a persistent form (a type) pertaining solely to itself, with the power of successively reproducing the same form, and none other;" and this gentleman has not hesitated to base these "primary organic laws" upon the evidence of a single specimen, and in some cases even the fragments of one have offered him a sufficient inducement!

But it has been argued by some that a wide variation may be the case with many species. Prof. Agassiz,[3] at a meeting of the American Academy, reiterated his opinion that what are called varieties by naturalists do not in reality exist as such. He found a great abundance of diverging forms in Echinoderms, which, without acquaintance

[1] "Proceedings of the Boston Society of Natural History," vol. v., pp. 121–128.

[2] *Proceedings of Cincinnati Society of Natural Science*, No. 1, June, 1876.

[3] "Proceedings of the American Academy," vol. v., p. 72.

with connecting ones, would be deemed distinct species, but he found they all passed insensibly into each other.

Prof. Parsons suggested that more extended observations might connect received species by intermediate forms, no less than so-called varieties; and Prof. Gray remarked that the intermediate forms, connecting by whatsoever numerous gradations the strongly divergent forms with that assumed as a type of a species, so far from disproving existence of varieties, would seem to furnish the best possible proof that these were varieties. Without the intermediate forms they would, it was said, be taken for species; their discovery reduced them to varieties, between which (according to the ordinary view), intermediate states were to be expected.

Recognizing, then, the existence of varieties, and of varieties sufficiently pronounced to have led careful naturalists to regard them as distinct species, what shall we say when it is found that these marked forms are correlated with certain physical conditions, many of which have originated within comparatively recent times? Dr. J. G. Cooper,[1] after a careful study of the California land snails, ascertained that "species, sub-species, and varieties, living in cool, damp situations, become more highly developed (but not always larger) than the others; the shell assuming a more compact (imperforate) form, and losing those indications of immaturity referred to, viz., sharp, delicate sculpture, bristles, and angular periphery. These characteristics, however, remain more or less permanently for indefinite periods, and give that fixedness to the various forms, even when living under the same conditions, which enables us to retain them as sub-species differing from varieties in permanency, and from races in not inhabiting distinct regions." It may be added that Stearns, Bland, and Binney, have likewise observed the same peculiar variations associated with aridity.

In a broader field, and compassing different classes, Prof. Spencer F. Baird, Mr. J. A. Allen, and Mr. Robert Ridgway, have severally shown that marked and specific changes are seen in birds and mammals corresponding to differences in their surroundings. Prof. Baird, in a paper entitled "The Distribution and Migration of North American Birds,"[2] has shown that birds in high altitudes and those bred at the North are larger than those born South and at low altitudes; that Western birds of the same species have longer tails than eastern examples, and that the bill increases in size in those birds occurring in Florida as compared with those found north of that State, and that on the Pacific coast the birds are darker in color than those found in the interior.

Mr. J. A. Allen[3] has made a more special study of this matter, and

[1] "Proceedings of the California Academy of Natural Science," vol. v., p. 128.

[2] *American Journal of Science and Arts*, vol. xli., January and March, 1866.

[3] "Proceedings of the Boston Society of Natural History," vol. xv., p. 156.

his work ranks among the most important contributions to this science. Mr. Allen finds that there are marked geographical variations in mammals and birds. He shows that northern mammals of the same species are more thickly and softly furred, and that toward the south the peripheral parts, such as the ears and feet, are more developed. The same law holds good in birds, a diminution in size being observed toward the south, and the individuals being darker in color.

As one goes south he meets with the same species of birds, whose bodies are shorter, but whose beak, tail, and claws, are longer. On the Plains, also, he found the birds with plainer tints, while southward the colors became more intense. On drawing up a table indicating the regions of lighter varieties, and comparing it with a chart of mean annual rainfall, Mr. Allen found the lighter forms occurred in dry regions, and the dark forms in relatively humid regions. To sum up: Mr. Allen finds in latitudinal variation climatic influences affecting color as well as altering the size of bill, claw, and tail, while longitudinal variation usually affects color alone.

He states that these laws are now so well known that a species may be predicted to assume a given color if under certain specific climatic conditions.

Mr. Robert Ridgway[1] has in a similar way called attention to the relation between color and geographical distribution in birds as exhibited in melanism and hyperchromatism, and has shown that red areas "spread" or enlarge their field in proportion as we trace certain species to the Pacific coast, and that in the same proportion yellow often intensifies in tint.

The results of these investigations can be easily understood. Nearly if not quite one hundred and fifty species of birds, which were recognized as distinct, are at once reduced to varieties, though less than twelve years ago they were looked upon as good species, with which no external influence had anything to do. Nearly if not quite a fifth of the number of species of birds have been reduced by the investigations of Baird, Allen, Coues, and Ridgway.

The mammals, through the same study of geographical variation, will have been reduced at least one-fourth. Already Mr. Allen[2] has studied the geographical variation of the squirrels, and the result is that a reduction has been made of one-half the number of species before recognized. Prof. Baird, in his monograph of North American squirrels, reduced the number from twenty-four, as acknowledged by Audubon and Bachman, to ten well-established species and two doubtful varieties. Allen, with still greater advantage in the shape of a mass of material from the Western surveys, reduced the ten species to five species, with seven geographical varieties.

[1] *American Journal of Science and Arts*, vol. iv., December, 1872, p. 454, and vol. v., p. 39.

[2] "Proceedings of the Boston Society of Natural History," vol. xiv., p. 276.

Should it be urged that the present tendency toward reducing species be taken as an evidence that species had not before been properly defined, then it offers a stronger argument still in favor of the fact that species are even more variable than had before been supposed, leaving the greater possibility of larger numbers of these ultimately surviving. Again, the assumption that the limitation of specific variation had not been properly indicated, shows how reprehensible has been the work of some of those who have burdened our literature with their bad species.

The fact is, the work has in a measure been justifiable, and is not to be wholly condemned. The workers in this line have followed the teachings of their masters. A group of individuals removed from an allied group of individuals by an extra dot or darker shade, perpetuating their kind from generation to generation, marked with persistent characters, and in every way coming up to the standard recognized as specific, had the right to be judged as such. It is only when a whole series of forms are collected, and climatic influences are seen to affect these in the same way that they affect other groups of species even in different classes, that the mere influence of moisture and temperature is shown to be the sole cause of many of these supposed specific characters.

Dr. A. S. Packard, in his remarkable monograph of a group of moths, the *Phalænidæ*, published under the auspices of the Hayden Survey, finds that with some species there are changes analogous to those pointed out by Baird and Allen; and while he does not find enough to establish a law, yet to his mind enough is seen "to illustrate how far climatic variation goes as a factor in producing primary differences in faunæ within the same zones of temperature," and he admits that varietal and even specific differences may arise from these climatic causes alone. Dr. Packard, in the same work, under the head of "Origin of Genera and Species," says, "The number of so-called species tends to be reduced as our specimens and information increase." The genera also "are as artificial creations as species and varieties. The work of the systematic biologist often amounts to but little more than putting Nature in a strait-jacket."

An application of the influence of temperature is here proper, as explaining, on a rational ground, the persistence of peculiar arctic forms of animals and plants on the summits of Mount Washington and other high peaks. With a knowledge of glacial phenomena, we are capable of judging the condition of things which must, of necessity, have existed directly after the recedence of the great ice-sheet: its southern border slowly retreating, and, with the encroachment of the warmer zone, the arctic forms dying out, or surviving under changed conditions; but, in high plateaus and mountains, local glaciers flourished for a while, and at their bases arctic forms flourished, and, lingering too long, were ultimately cut off by the retreat

of the main field. This interpretation of arctic forms on high peaks, though attended to by several American naturalists, is not new. Oswald Heer, in discussing the origin of certain animals and plants, coincides with De Candolle that Alpine plants are relics, as it were, of a glacial epoch. Prof. Gray[1] had also independently arrived at the same conclusions, based on a comparison of the plants of Eastern North America and Japan. In the position he maintained regarding the derivation of species from preëxisting ones, he stood far in advance of his brother naturalists in this country, for this was before Darwin's great work had appeared, and before Heer had developed the host of fossil plants from the arctic zone. Mr. S. I. Smith, in speaking of mountain faunæ, points out the gradual encroachment of glaciers, and the drawing down of northern forms; and, as the glaciers retreated, these forms were caught, "the mountain-summits being left as aërial islands." Dr. Packard and Mr. Scudder have severally called attention to the same thing.

Prof. A. R. Grote has more fully dealt with the subject in a paper read before this Association, and in a graphic way shows that the "former existence of a long and widely-spread winter of years is offered in evidence through the frail brown Œneis butterflies, that live on the top of the mountains within the temperate zone." I have been thus explicit, in order to contrast these more rational views with those formerly entertained by eminent naturalists, whose minds were imbued at the time with the idea of special creation. Mr. Samuel H. Scudder[2] read before the Boston Society of Natural History an account of distinct zones of life on high mountains, as illustrated in the insect-life of Mount Washington. He called attention to certain insects which he supposed peculiar to the summit, and not found farther north, though showing a remarkable correspondence to certain arctic forms. Prof. Wyman asked whether all the facts might not be accounted for on the theory of migration northward after a glacial epoch, and Prof. Rogers suggested that the facts might be accounted for on the migratory theory if we added thereto the supposition of subsequent variation induced by isolation. Yet these views were persistently opposed by the other naturalists present. The mass of evidence already contributed, as to the extraordinary variation in color, markings, and size of species coinciding with their physical surroundings, though perhaps trivial in itself, becomes important when the proofs are grouped together, and all bear upon the theory of derivation. So slight a thing as change of food is found to influence certain animals even to a degree usually regarded specific. The late Dr. B. D. Walsh[3] discovered some very curious features among in-

[1] "Memoirs of the American Academy," vol. vi., pp. 377–458 (1859).

[2] "Proceedings of the Boston Society of Natural History," vol. ix., p. 230.

[3] "On Phytophagic Varieties and Phytophagic Species," "Proceedings of the Entomological Society of Philadelphia," vol. iii., p. 403.

sects connected with a change of food. First, he established the fact that insects accustomed to one kind of plant could acquire a taste for another kind, and he has shown that in thus changing the food of the insect a change took place in the appearance of either the larva, pupa, or imago, and sometimes all three stages were affected. Dr. Fitch had observed that changing an insect's larva from the leaf to the fruit affected the appearance of the larva. It would be impossible to give even an abstract of Dr. Walsh's remarkable essay. It may be said, however, that his investigations led him irresistibly to the conclusion that the present species have been derived from preëxisting ones, and in numberless cases he is capable of showing the successive stages from the dawn of a plant-eating variety, where the changes are slightly seen in the larva only, to the plant-eating species in which profound changes are seen in the larva, pupa, and imago.

The minor factors of natural selection, such as protective coloring and mimicry, have been variously illustrated by Mr. R. E. C. Stearns, Dr. Kneeland, Prof. Cope, Dr. Charles C. Abbott, and others. In a special paper on "The Adaptive Coloration of Mollusca," [1] I have endeavored to show not only a wide-spread application of this feature to mollusks, and especially those exposed by the tide, but in some cases a mimicry of inanimate objects, as the accumulation of clay or grains of sand upon the shell.

Wallace's theory of birds'-nests finds interesting confirmations in the observations of Dr. Abbott, who made a special study of a large number of robins'-nests, and found the widest variation among them. He studied also the nests of the Baltimore oriole, where, according to the theory of Wallace, a concealing nest should be made, the bird being exceedingly bright-colored. He found that, away from the habitations of man, the orioles built concealing nests; but in villages and cities, on the other hand, where they were in no special danger from predatory hawks, the nests were built comparatively open, so that the bird within was not concealed.[2]

The differences in the habits of animals of the same species are noticed in different parts of the country, and such facts militate against the idea that certain unerring ways were implanted in them at the outset. Indeed, such facts go to show that these various creatures not only become adapted to their surroundings, but that individual peculiarities manifest themselves. The observations of Dr. Coues, Mr. Allen, and Mr. Martin Trippe, go to prove that certain birds change their habits in a marked degree. In their behavior, too, certain birds, which are wild and suspicious in New England, are comparatively tame in the West. In their resting-places they show wide individual variation.

[1] "Proceedings of the Boston Society of Natural History," vol. xiv., p. 141.

[2] POPULAR SCIENCE MONTHLY, vol. vi., p. 481.

Prof. A. E. Verrill,[1] on the supposed eastern migration of the cliff-swallow, traces historically its first appearance in various places in the East, and is inclined to the opinion that as the country became settled by Europeans the birds left their native haunts for barns and houses, and increased in number to a greater extent than before on account of the protection invariably furnished by man.

Rev. Samuel Lockwood[2] records a curious case of the Baltimore oriole acquiring a taste for the honey-sacs of bees, tearing off the heads of those insects, and, having secured the honey-sacs, rejecting the rest of the body.

Prof. Wyman[3] observes a curious case in Florida of a colt and a number of pigs and cows thrusting their heads under water and feeding on the river-grass, in some cases remaining with their heads immersed for half a minute.

Hon. A. H. Morgan[4] observes the widest difference in the habits of the same species of beaver in the Lake Superior region and in the Missouri, constructing their dams and ways differently, and meeting the varied conditions, not by a blind instinct, but by a definite intelligence manifested for definite purposes.

All of these facts, simple in themselves, yet together go to prove that animals do vary in their habits, and with a persistent change in habits arises the minute and almost insensible pressure to swerve and modify the animal.

So much does the influence of season, with its accompanying peculiarities of food, temperature, humidity, and the like, affect certain animals developing coincidently with its different phases, that it is instructive to note that in certain species of insects two or three different forms occur. Thus Mr. Edwards[5] has in an elaborate way worked up the history of a polymorphic butterfly (*Ephiclides ajax*), showing that there are three forms heretofore regarded as distinct species, which are only varieties of one and the same species, but appearing at different times of the year, and consequently confronted by different influences as to temperature, moisture, food, and the like. These forms are known under the names of *Walshii*, *Telemonides*, and *Marcellus*, and both sexes are equally affected. The first form mentioned represents the early spring type, *Telemonides* the late spring type, and *Marcellus* the summer and autumn type (*see* also Mr. Scudder's paper[6]). If these influences affect species, we should expect to see the greatest variety of forms in a country possessing the widest diversity of conditions.

Some suggestive paths of investigation have been pointed out by

[1] "Proceedings of the Boston Society of Natural History," vol. ix., p. 276.
[2] *American Naturalist*, vol. vi., p. 721. [3] Ibid., vol. viii., p. 237.
[4] "The American Beaver and his Works."
[5] "Butterflies of North America," part ix.
[6] *American Naturalist*, vol. viii., p. 257.

Prof. N. S. Shaler [1] on the connection between the development of the life and the physical conditions of the several continents, showing first that the greatest amount of shore-line in proportion to the internal areas indicates a greater diversity of surface within.

Another proposition he attempts to establish: that in proportion to the shortness of the shore-lines, or, in other words, to the want of variety in their surfaces, will be the diversity of animal life in the continent. He then proceeds from Darwin's standpoint, and follows out many curious and instructive lines of thought regarding increased amount of influences in diversified surfaces—a level plain having the same conditions throughout, but a mountainous region having for each one thousand feet of elevation a new condition of things, in the form of streams, winds, humidity, and the like. In areas of simple outline and unvarying surfaces we do, in fact, have a less diversity of forms.

Recognizing the mutation of continents through past geologic ages, we again see the accompanying physical changes in not only modifying forms, but in selecting them afterward by succeeding changes.

The widely-diversified nature of the facts bearing on the doctrine of natural selection baffles all attempts at a systematic classification of them. Of such a nature are many of the valuable communications of Prof. Wilder.

At the meeting of this Association [2] he has, among other matters, confirmed in a young lion the discovery of Prof. Flowers that, in the young dog and probably in other carnivora as well, the scapho-lunar bone has at the outset three centres of ossification, and that these really represent the *radiale intermedium* and *centrale* of the typical carpus. By study of a fœtal manatee, Prof. Wilder is able to determine its affinities, and to point out the probable retrograde metamorphosis of some ancient ungulate animal, and that the manatee is widely removed from the whales with which it has been associated.

Mr. William K. Brooks has published a very remarkable paper on certain free swimming tunicates, the *Salpa*, giving for the first time a clear and comprehensive history of certain obscure points, and has at the same time applied the principles of natural selection theoretically in showing the origin of salpa from sessile tunicates, and making clear the peculiar modification of parts which accompany these changes.

In the field of entomology some capital work has been done, both practical and theoretical.

Prof. Riley's demonstration of the yucca-moth is unique in its way. Dr. Engelmann has discovered that the yucca depends upon insects for fertilization; and Prof. Riley, by patient study, not only

[1] "Proceedings of the American Academy," vol. viii., p. 349.

[2] "Proceedings of the American Academy of Arts and Sciences," vol. xxii., p. 301.

discovered the moth which fertilizes the flower, but finds an anomalous change in the maxillary palpi of the insect, by means of which the moth collects bundles of pollen, which it inserts into the stigmatic tube, and during this peculiar act deposits her eggs in the young fruit. Prof. Riley has reasons to believe that this is the only insect engaged in the fertilization of this plant. A mutual dependence is here met with of extreme interest. The yucca unfertilized forms no fruit, and the larva of the moth consequently perishes.

Prof. Augustus R. Grote, in an examination of butterflies, finds successive gradation in their structures, and shows that as these organs "become less serviceable to the insect they become more rigid and in position more elevated above the head in the butterfly, while in the moth they are more whip-like and directed forward." While protesting against the separations which have been made in the order based upon the antennæ, he directs attention "to the real differences in antennal structure between the butterflies and moths, while showing that the antennæ are modified by desuetude in the higher and former group." Prof. Grote,[1] in dealing with a family of moths, the *Noctuidæ*, calls attention to the unequal value of *Acronycta*, and is forced to admit that these differences become clear through the theory of evolution. He says: "Where in *Acronycta* there is a general prevailing uniformity in the appearance in a single group of species and generally broad distinctions between the larval forms, it is a not unreasonable conclusion that these larval differences are gradually evolved by a natural protective law, which intensifies their characters in the direction in which they are serviceable to the continuance of the species."

Those who have believed in types as fixed laws, rigidly impressed at the outset of life, are those also who have recognized in the cells of a honey-bee, as well as in the arrangement of leaves about the axis of a plant, a perfect mathematical adjustment of parts, which were stamped at the beginning, and have so continued to exist without deviation. For nearly two hundred years it has been believed that the instinct of a bee guided it to shape a cell which of all other forms should use the least amount of material. A theory having been established as to the constant shape of a bee's cell, namely, that it was an hexagonal prism with trihedral bases, each face of the base being a rhomb with certain definite angles, a mathematician was given the problem to construct similar cells, and to determine the best possible form with the use of the least amount of material. The coincidence between theory and observation and experiment was so remarkable as to settle apparently for all time the question as to the perfectly-implanted instinct of the bee with its unconscious power of accurate work. Prof. Jeffries Wyman,[2] to whose memoir I am indebted

[1] "Proceedings of the Buffalo Society of Natural Science," vol. i., p. 130.

[2] "Proceedings of the American Academy," vol. vii., p. 68.

for the above facts, has by an ingenious study of the cells of bees shown, first, that, a cell of this perfection is rarely if ever attained. Furthermore, that, while the honey-cells "are built unequivocally in accordance with the hexagonal type, they exhibit a range of variation which almost defies description;" that the worker-bees, from incorrect alignment and other causes, build cells, the measurement of which shows the widest limit of variation; that the drone-cells are liable to substantially the same variations, while the transition-cells, namely, those in which drones and worker-cells are combined in the same piece of comb, are extremely irregular. As the drone-cells are one-fifth larger than worker-cells, "a transition cannot be made without some disturbance in the regularity of the structure." And Prof. Wyman states distinctly that the bees do not have any systematic method of making the change, adding that "the cell of the bee has not that strict conformity to geometrical accuracy claimed for it," and the assertion, like that of Lord Brougham, that there is in the cell of the bee "perfect agreement between theory and observation, in view of the analogies of Nature, is far more likely to be wrong than right, and his assertion in the case before us is certainly wrong." Prof. Wyman closes his essay by saying that "much error would have been avoided if those who have discussed the structure of the bee's cell had adopted the plan followed by Mr. Darwin, and studied the habits of the cell-making insects comparatively, beginning with the cells of the humble-bee, following with those of the wasps and hornets, then with those of the Mexican bees, and finally with those of the common hive-bee; in this way they would have found that, while there is a constant approach to the perfect form, they would at the same time have been prepared for the fact that even in the cell of the hive-bee perfection is not reached. The isolated study of anything in Nature is a fruitful source of error."

The remarkable ingenuity, so characteristic of Prof. Wyman's experiments, is fully shown in this memoir. He made plaster-casts of the comb, and then sawed transverse sections, and by slightly heating the plaster the wax was melted and absorbed, leaving the delicate interspaces representing the partitions. From these sections electrotypes were taken, and thus the veritable figures were used to illustrate the absolute structure of the comb. The results of these brilliant researches were published in the "Proceedings of the American Academy of Sciences."

[*To be continued.*]

THE EARLY HISTORY OF FIRE.[1]

By Professor N. JOLY,
OF THE FACULTY OF SCIENCES, TOULOUSE.

FIRE, the common source of heat, of light, and of life, and the active principle of a multitude of industries, and of metallurgical industry in particular, is unquestionably one of the greatest conquests achieved by man over Nature.

The discovery of fire was more than a benefit; it was, in fact, a giant stride on the road to civilization. With fire arose sociability, the family, the sacred joys of the domestic hearth, all industries, all arts, together with the wonders they have produced, and still produce from day to day. Hence we can readily understand how it is that fire has ever been and still is, among many nations, the object of a special worship (priests of Baal, Ghebers, Hindoo Brahmans, Roman vestals, priestesses of the sun in Peru, etc.); and that it has often figured in the religious or funereal rites of nations most remote from one another, both in time and space, as the Chaldees, Hebrews, Greeks, Romans, Peruvians, Mexicans, etc. But how and when was this great discovery made, in the absence of which we can hardly conceive of the possibility of human arts or even of human existence? Did man, as we are told in the myths of India and Greece, steal fire from heaven; or did he, as other legends affirm, take advantage of spontaneous forest-fires, arising from the violent rubbing together of dry branches under the action of the wind; or, finally, was man so ingenious, even from the beginning, as to devise one of those simple and practical contrivances by means of which certain savage and half-civilized tribes in our own time obtain the fire they need for their daily uses?

However far back we may trace man's history, we find him always in possession of fire. The story of Prometheus getting fire from Olympus is nothing but the Vedic myth which tells of the god Agni, or heavenly fire (Latin, *ignis*), as squatting in a hiding-place whence he is compelled by Matarichvan to come forth in order to be communicated to Manu, the first man, or to Bhrigu (*the shining one*), the father of the sacerdotal family of the same name.

The very name of Prometheus is of purely Vedic origin, and calls to mind the process employed by the ancient Brahmans in getting the sacred fire. For this they used a spindle called *matha* or *pramatha*, the prefix *pra* adding the idea of *taking by force* to the signification of the root *matha*; this latter is from the verb *mathnâmi*, or *manthâmi*—"to bring out by friction." Prometheus, therefore, is the one who discovered fire, brings it forth from is hiding-place, steals it and gives it

[1] Translated from the French by J. Fitzgerald, A. M.

to mankind. From Pramanthâ, or Prâmâthyus—"he who hollows out by rubbing," "he who steals fire"—the transition is easy and natural, and there is only one step from the Indian Prâmâthyus to the Prometheus of the Greeks, who stole the heavenly fire to light the spark of life, the soul, in the clay-formed man.

The spindle or *pramantha* had wound round it a cord of hemp mixed with cow-hair, and with this cord the priest of Brahma gave it an alternating rotary motion from right to left and from left to right. In rotating the spindle, one end of it rested in a depression made at the intersection-point of two crossed pieces of wood, the ends of which were bent to a right angle, and firmly secured with four bronze nails, thus preventing them from moving. The entire apparatus was called *swastika*.[1] The father of the sacred fire was named Twastri, i. e., the divine carpenter who made the *swastika* and the *pramantha*, the mutual rubbing of which together produced the divine babe Agni. Its mother was named Maya. Agni took the name of Akta (i. e., *anointed*, christos) after the priest had poured on its head the *soma*, and on its body the purified butter of the sacrifice.

In his interesting work on the "Origin of Fire," Adalbert Kuhn gives to the and to this other like sign, , the name of *arani*, and both of them he regards as the religious symbols, *par excellence*, of our old Aryan ancestors—the symbols of sexual reproduction.

This fire-myth occurs also in the Zendavesta, or sacred book of the Persians, and in the Vedic hymns of the Hindoos, under a twofold form, both material and metaphysical. But the authors of these hymns bear witness that this same myth was, long before their time, symbolized in a great national religion, the founder of which, Rhibu, is no other than Orpheus. This tradition, common to Greeks, Hindoos, and Persians, carries us back to those ancient times when the as yet undiscovered branches of this stock wandered upon the banks of the Oxus.

In his "Researches into the Early History of Mankind," Tylor gives interesting details about the discovery of fire, and the various modes of obtaining it in every age. The primitive method of all would seem, according to him, to have consisted in rubbing together two pieces of dry wood, but this process was perfected in the course of time. Thus, friction is produced by means of a stick which is made

[1] It is well worthy of note that the *swastika*, , of India occurs very frequently in two forms, viz., and , on the earthen-ware disks found in such great numbers by Dr. Schliemann among the ruins of ancient Ilium. From this it would seem to follow that the Trojans were of Aryan origin. As for the analogies, or even direct resemblances, between certain ceremonies to the worship of Agni and certain rites of the Catholic worship, they, too, may be explained, at least to some extent, by community of origin: Agni, as *Akta*, would be Christ; Maya, the Virgin Mary; Twastri, Saint Joseph.

to slide rapidly to and fro upon a piece of dry, soft wood laid upon the ground (in Tahiti, the Sandwich Islands, New Zealand, Timor, etc.). This process Tylor denominates the stick-and-groove (Fig. 1), but the fire-drill (Figs. 2 and 4) is more generally used. In its simplest form, the fire-drill consists of a stick, one extremity of which is inserted in

FIG. 1.—THE STICK-AND-GROOVE. (Tylor.)

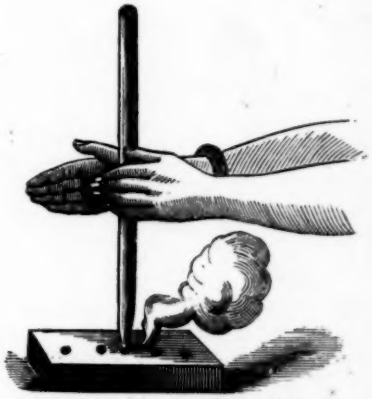


FIG. 2.—THE FIRE-DRILL. (Tylor.)

a hole bored in a piece of dry wood, while the stick itself is twirled between the hands and pressed downward (*see* Fig. 2).

This instrument occurs not only in Australia, Sumatra, the Caroline Islands, and Kamtchatka, but also in China, South Africa, and North and South America. It was employed by the ancient Mexicans, and is still in use among the Yenadis of Southern India, and the Veddas of Ceylon (Fig. 3).

FIG. 3.—ANCIENT MEXICAN FIRE-DRILL. (Tylor.)

It is still further modified by causing the stick to whirl by means of a thong wound round it, the ends of which are pulled in opposite directions alternately. This is the instrument described in the Vedas, and it is still employed by the Brahmans of our own day for lighting the sacred fire. For, as Tylor well observes, we very often see fire obtained for use in religious rites by the ancient processes,

rather than by the readier means discovered in later times. Thus, when the vestals permitted the sacred fire to go out, it was rekindled by means of the sun's rays, concentrated by a lens. A similar method was employed by the ancient priests of Peru in kindling the sacrificial fire.

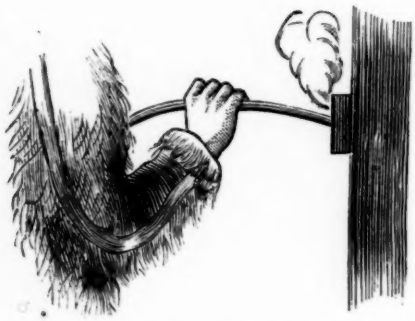


FIG. 4.—FIRE-DRILL OF THE GAUCHOS. (Tylor.)

An instrument resembling that employed by the Brahmans of India is to this day in use among the Esquimaux and the Aleuts (Fig. 6). It consists of a rod, one end of which fits into a mouth-piece, and the other into a hole in a piece of dry wood. The rod is twirled by means of a thong wound twice around it, and pulled to the right and left alternately by the hands.

Slight modifications occur in the form of the fire-drill, and various instruments have been devised to serve the same purpose. For instance, there are the bow-drill and the pump-drill, which latter is used both for obtaining fire and for boring holes in wood, stone, and metal (Figs. 5 and 7).

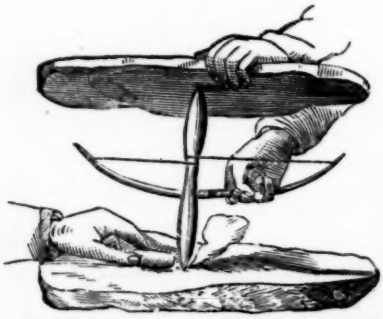


FIG. 5.—BOW-DRILL, USED BY THE SIOUX. (Tylor.)

Of other means of procuring fire we will simply mention, in passing, the striking together of flints, or flint and steel, or iron pyrites; striking together two pieces of bamboo (this method peculiar to China); compressing air in a tube of ivory or of wood (a process adopted by the Malays, etc.).

The dried parenchyma of the *Boletus igniarius*, frayed cedar-bark, dry leaves, carbonized vegetal fibres, and the like, are the combustible materials commonly employed to receive the spark produced by friction or by concussion.

Is there or has there ever been a people absolutely ignorant of the means of producing fire? Many authors answer this question affirmatively. Thus we are told that the natives of Tasmania, though acquainted with fire and making use of it, nevertheless are ignorant of the means of producing it. Hence it is the special duty of their women to carry fire-brands that burn day and night, and by the light of which the tribe make their way through the woods. If the torches or brands go out, it may be necessary to make a long journey in order to have them lighted again from the fire kept up by another tribe. Nearly every family, too, carries about a cone of banksia, which burns slowly like amadou.

FIG. 6.—ESQUIMAU THONG-DRILL. (Tylor.)

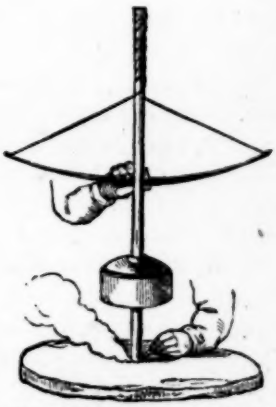


FIG. 7.—PUMP-DRILL. (Tylor.)

That the Australians are not so ignorant of the uses of fire as they are said to be, is shown by a legend current among them about the origin of fire. This legend we copy from Wilson, who, in his work, "Prehistoric Man," devotes a highly-interesting chapter to the question we are considering: "A long, long time ago, a little bandicoot[1] was the sole owner of a fire-brand, which he cherished with the greatest jealousy. So selfish was he in the use of his prize that he obstinately refused to share it with the other animals. So they held a general council, where it was decided that the fire must be obtained from the bandicoot either by force or strategy. The hawk and the pigeon were deputed to carry out this resolution; and, after trying to induce the fire-owner to share its blessings with his neighbors, the pigeon, seizing, as he thought, an unguarded moment, made a dash to obtain the prize. The bandicoot saw that affairs had come to a crisis,

[1] A small, sharp-nosed animal, not unlike the Guinea-pig.

and, in desperation, threw the fire toward the river, there to quench it forever. But, fortunately for the black man, the sharp-eyed hawk was hovering near, and, seeing the fire fall into the water, with a stroke of his wing he knocked the brand far over the stream into the long, dry grass of the opposite bank, and the flames spread over the face of the country. The black man then felt the fire, and said it was good." [1]

Did prehistoric man possess fire? If we are to believe the Abbé Bourgeois, man was in possession of fire since Miocene times. This assertion rests upon the discovery in the sands of the Orleanais of a fragment of artificial *paste* [2] mixed with charcoal, and lying in the midst of mastodon and dinotherium bones. It also rests, but not so firmly, upon the discovery by the same *savant* of cracked flints in the neighborhood of Thenay, not far from the banks of the lake of Beauce. These flints appear to bear plain traces of the action of fire; but may not these be due to lightning? If not, where are the ashes, where the charcoal which naturally would accompany the flints if they had been really brought under the action of fire? Then, where is the fireplace? Hence, the Abbé Bourgeois's deduction is not an impossible one, though in my opinion it is by no means demonstrated.

But, though the discovery of fire in Miocene times may be questioned, it cannot be denied that in the earliest Quaternary times this element was known to man. Several fireplaces, ashes, charcoal, bones, either entire or partly calcined, fragments of coarse pottery blackened by smoke, and similar objects, have been found in caverns belonging to the epoch of the Cave Bear, and of the Reindeer and the Polished Stone age. These things prove that the men who inhabited the caves commonly enough cooked their food, thus making it more readily digestible.

With the aid of fire, prehistoric man cremated his dead, hollowed out his pirogue, and saved from too rapid destruction the lower extremity of the piles on which he built his lake-dwellings. And not only did the troglodyte and the lacustrian know how to cook their food and warm their habitations, but they also were acquainted with various methods of lighting them during the darkness of night. There have been found in the Lake of Geneva carbonized sticks of resinous wood, which, in all probability, once were employed for this latter purpose. Just as the Esquimaux now light their snow huts by means of lamps fed with the oil of the porpoise or the whale, so did the Danes of the kitchen-middens use, for illuminating purposes, a wick made of moss, one end of which was introduced into the stomach of a great penguin (*Alca impennis*) filled with fat.

The use of flint, quartz, and iron pyrites, in the Lacustrian period, for procuring fire by striking these substances against one another, is

[1] Vol. i., p. 139.

[2] Paste, the mineral substance in which other minerals are imbedded.—Webster.

proved by the discovery, in the lakes of Switzerland (at Meilen, Moosseedorf, Wangen, and Robenhausen), of bits of tinder prepared from the *Boletus igniarius*. And, if we accept the views of Messrs. Ed. Lartet and Christy with regard to certain blocks of granite, hollowed out in the centre, which have been found in the caves of Périgord, these blocks would appear to have been intended for the purpose of procuring fire by rapidly rotating a wooden rod in the central cavity, as is done by the priests of Brahma.

And, indeed, how could it happen that fire should have been unknown even in the earliest periods of Quaternary time, considering the chances of fire being struck from these flints, whether in the workshop or in battle, and of the sparks falling upon combustible materials—for instance, dry leaves? This explanation we hold to be simpler and more natural than the other, which refers the discovery of fire to the spontaneous conflagrations of forests, or to the friction of dry branches of trees.

Fire, we repeat with profound conviction, must have been very early known to man, for we cannot conceive of his living without it. And hence, "who can picture the joy, the gladness, the radiant ecstasy of that one of our unknown forefathers who first triumphantly exhibited to his astonished tribesmen the smoking brand from which he had succeeded in causing flame to burst forth?" [1]

Thus we have seen that fire gave rise to nearly all the arts, or at least promoted their development. Metallurgy, architecture, ceramic arts, agriculture, navigation, commerce, industry, all are quickened by its vivifying flame. It has played, and still does play, an important part in the religious ceremonies and the funereal rites of nations, both savage and civilized. But then, in turn, as though by a law of Fate, evil accompanies the good: fire destroys with greater rapidity than it produces by forging those formidable engines, those implements of death, by which in the twinkling of an eye the flower of nations is cut down on the battle-field.—*Revue Scientifique.*

PHYSICAL SCIENCE IN ENGLISH SCHOOLS.

AT a meeting of the British Association five years ago, the subject of science-teaching in our higher schools excited unusual interest. Not only were papers read and followed by enthusiastic discussion, but a committee was privately formed, including more than twenty leaders of the Association, all of whom undertook to combine in pressing the claims of science on our head-masters, and in offering counsel as to systems and methods, apparatus, and expenditure.

[1] Albert Réville, *Revue des Deux Mondes*, tome xl.

Technical difficulties prevented the formal nomination of the committee in that year; and before the next meeting came round the Science Commission was in full work, and the ground was covered. Five years have passed; the commission has reported; and the British Association, if it deals at all with the problem that lies at the root of our scientific progress, will have to face the fact that only ten endowed schools in England give as much as four hours a week to the study of science; in other words, that, in spite of ten years of talk, the *éclat* of a Royal Commission, a complete consensus of scientific authority, and the loud demands of less educated but not less keen-sighted public opinion, the organization and practical working of science in our higher schools has scarcely advanced a step since the Schools Inquiry Commission reported in 1868.

Are the causes of this strange paralysis discoverable, and are they capable of present remedy? We believe that they are notorious, and that it is in the power of the British Association at the present moment to overrule them. It is therefore in the hope of rekindling a productive enthusiasm at a critical moment in the history of our science-teaching that we appeal with all the earnestness of which we are capable to the leaders of the great parliament, whose session will have opened before this goes to press.

The first obstacle to be understood and reckoned with is the amazing confusion in the minds of unscientific leaders of opinion as to the very nature of education. An ex-Lord Chancellor gives away prizes to a school, declares in stately terms that Greek and Latin must always form the backbone of high intellectual training, and that the sciences can only be tolerated as a sort of ornament or capital to this great central vertebral column. On the following day an ex-Chancellor of the Exchequer gives away prizes at another school, assures the boys that modern scientific teaching is their being's end and aim, and envies them by comparison with himself, who at Winchester and Oxford basked only in the "clarum *antiquæ* lucis jubar."[1] In all such public utterances chaos reigns supreme. Men take side with one or other branch of mental discipline, unconscious of the Nemesis which waits on the divorce of literature from science, or of science from literature, forgetful of the fundamental truths that all minds require general training up to a certain point, and that the period at which special education should supervene is the problem which awaits solution.

The hostility of the clergy ranks high among the difficulties we have to recognize. To the great public schools this is matter of indifference; but the vigorous head-master of a young and rising county school, who attempts, being himself a clergyman, to make real science compulsory in his school, is rattened by the vulgar heresy-hunters, who swarm in every diocese. The hint and shrug in society, the whisper at clerical conferences, the warning to parents attracted

[1] The bright radiance of *ancient* light.

by the school against "atheistic tendencies," keep down his numbers and wear out his energies, till his enterprise becomes a warning instead of an example to his admirers at other schools. In a neighborhood of rural squires and clergy, untempered by a large town's neighborhood, and unchecked by any man of education and intelligence holding sovereignty by virtue of superior rank and wealth, a school which treads doggedly in the ancient paths, and is flavored with gentle "High-Church tendencies," will certainly succeed even in second-rate hands, while a school which under superior chieftainship asserts the claims of science, and whose theology is therefore suspect, will as certainly long struggle for existence, if it does not finally succumb.

The head-masters, with no inveterate intention, but by the force of circumstances, are potent allies upon the side of nescience. Their position is peculiar. Enlightened, able, high-minded, and most laborious, to speak of them with disrespect would be to forfeit claim to a hearing. But of their whole number not more than two or three know anything at all of science; they have gained honors and supremacy by proficiency in other subjects; to teach well these subjects which they know, forms their happiness and satisfies their sense of duty; and they feel natural dismay at the proposal to force upon them new and untried work which they have not knowledge to supervise, and which must displace whole departments of classical study. Bifurcation they do not mind, for they hope that the dunces will be drafted into the modern school, and the clever boys retained upon the classical side; but the momentous recommendation of the Royal Commission that six hours a week of science-teaching should be given to every boy in every school has taken away their breath; it was only once alluded to at the last head-masters' meeting, and then with something between a protest and a sneer. They are too clear-sighted not to see that the demand for science-teaching is real, and too liberal not readily to accede to it, if some central authority, which they respect, at once puts pressure on them, and tenders such assistance and advice as they can trust. But, until these two things are done, they will pursue a policy of inaction.

Nor is there any hope that this reluctance of head-masters will be stimulated by exuberant energy on the part of governing bodies. The instances in which these pet creations of the Endowed Schools Commission have appeared before the public hitherto make it evident that absolute inactivity is the service they are best calculated to render to the cause of education; but their probable devotion to science may be guessed from an incident reported in our columns some months ago, where a body of trustees, composed of country gentlemen of local mark, having to arrange a competitive examination under a scheme of the Charity Commission, adopted the machinery of the University Leaving Examination, but inserted a distinct proviso that no scientific subject recognized by the university regula-

tions should under any circumstances be taken up by the candidates, either as an alternative or a positive branch of work.

Will the universities help or impede the spread of school science-teaching? The universities adhere at present to their fatal principle that only one-sided knowledge shall find favor within their walls. A boy who knows nothing but classics, nothing but mathematics, nothing but science, may easily win a scholarship; a boy who knows all three must seek distinction elsewhere; and this rule shapes inevitably the teaching of the schools. The science scholarships at Oxford, of which we hear so much, fall mainly to three distinguished schools: two so large and wealthy that they can overpower most competitors by their expenditure on staff and apparatus; the third planted in Oxford, with access to the university museum and laboratory, and with a pick of teachers from the men of whom examiners are made; and these schools insure success in science by abandoning other subjects almost or altogether in the case of the candidates they send up. No school which should carry out the recommendations of the commissioners by giving six hours a week to science, and the rest of its time to literature and mathematics; no school which should realize its function as bound to develop young minds by strengthening in fair proportion all their faculties of imagination, reason, memory, and observation—could offer boys for any sort of scholarship under the present university system with the faintest chance of success.

What these institutions are powerless to avert or helpless to bring about is, we repeat, within the scope of the British Association to effect. All institutions, political or educational, will bow to a strongly-formed committee of scientific men, formally commissioned by the Association and speaking with authority, delegated as well as personal, on scientific subjects. Let such a committee be revived as died on paper in 1871, including the acknowledged leaders of pure science, and weighted with the names of such educationalists as have shown themselves zealous for science-teaching. Let their functions be—1. To communicate with the head-masters and governing bodies, calling attention to the recommendations of the Duke of Devonshire's commission, asking how far and how soon each school is prepared to carry these out, and tendering advice, should it be desired, on any details as to selection and sequence of subjects, teachers, text-books, outlay. 2. Let them appeal to the universities, to which many of them belong, as to the bearing of science scholarships and fellowships upon school-teaching, and the extent to which such influence may be modified or ameliorated in that rearrangement of college funds which next session will probably be commenced. 3. Let them be instructed to watch the action of Government in any proposal made either in pursuance of Lord Salisbury's bill, or as giving effect to the Duke of Devonshire's commission, and let them be known to hold a brief for school science in reference to all such legislation. A

single meeting of such a committee before the Association separates would settle a basis of action and compress itself into a working sub-committee. The time for papers and discussions is past; they have done their work. What the schools and the head-masters want is authoritative guidance—the guidance not only of a blue-book, but of a living leadership, central, commanding, and accessible, to which they may look with confidence, and bow without loss of prestige.

The precision of its *dicta* will clear up public confusion; its ability, conscientiousness, and popularity, will overawe the clergy; schools and universities will listen respectfully to suggestions echoed by their own best men; and the three great departments of intellectual culture, equal in credit, appliances, and teaching power, will bring out all the faculties and elicit the special aptitudes of every English boy.

"Hinc omne principium, huc refer exitum." [1]

—*Nature.*

NATURE OF THE INVERTEBRATE BRAIN.

By Professor H. CHARLTON BASTIAN.

II.

IT now remains for us to consider the disposition of the nervous system in some of the principal types of the sub-kingdom *Mollusca.*

These are animals wholly different in kind from those we have just been considering, mostly aquatic, and all of them devoid of hollow, articulated, locomotor appendages. Their organs of vegetative life attain a disproportionate development. On the other hand, what are termed the "organs of relation" present a wide range of variation, as may be imagined from the fact that while some of the simplest representatives of the *Mollusca* consist of mere motionless sacs or bags, containing organs of digestion, respiration, circulation, and generation, its more complex forms are active predatory creatures, endowed with remarkable and varied powers of locomotion, and with sense-organs as keen and as highly developed as those of insects. The lower type is represented by the motionless ascidian, and the higher by the active and highly-endowed cuttle-fish.

Omitting any reference to the *Polyzoa*, we may turn our attention first of all to the *Tunicata*, of which the solitary ascidians may be taken as the type. They are marine animals, possessing no powers of locomotion, and having no head. The current of sea-water, serving for respiratory purposes, and, at the same time, containing food-particles, enters a large branchial chamber, through an open, funnel-like projection of the investing tunic of the animal, the orifice of which

[1] With this begin, to this refer the end.

is guarded by sensitive tentacula and a sphincter muscle. The mouth is situated at the bottom of this branchial sac, down the side of which minute particles of food are swept by ciliary action, so as to be brought within the simple commencement of the œsophagus. The effete sea-water passes through the walls of this branchial cavity into a general body-chamber, in which the viscera are contained. This cavity is bounded externally by a muscular expansion, lining the outer cellulose tunic. By the periodical contraction of this muscular sac, the water which enters it, together with food-residues and ova, is expelled through another funnel-like opening, adjacent to and very similar to that by which it gains entry to the branchial chamber.

Although these ascidians have a definite alimentary canal, a circulatory system, and respiratory organs, together with a distinct genital apparatus, their life of relation with the external world is of the simplest description. They are stationary creatures, and have no prehensile organs, food being brought to the commencement of their alimentary canal by ciliary action.

In correspondence with such a simple mode of life, we might expect to find a very rudimentary nervous system, and this expectation is fully realized. The *Tunicata* possess a single small nervous ganglion lying between the bases of the two funnels through which water is taken in and discharged. This ganglion receives branches from the tentacula guarding the orifice of the oral funnel, and possibly from the branchial chamber, while it gives off outgoing filaments to the various parts of the muscular sac, and perhaps to the alimentary canal, and some of the other internal organs. In some of the solitary *Tunicata* a rudimentary visual function is presumed to exist. At all events, pigment-spots are situated on, or in very close relation with, the solitary ganglion. This single body seems to serve for the performance, in a rudimentary manner, of the various functions discharged by at least two pairs of ganglia in a large number of higher *Mollusca*, viz., those known as the cerebral and the parieto-splanchnic or branchial.

The brachiopods are among the oldest and most wide-spread of the forms of life in the fossil state, and the geographical distribution of their living representatives at the present day is also very wide. Like the *Tunicata*, they are headless organisms, and lead a sedentary existence, attached either by a pedicle or by one division of their bivalve shells. The mouth is unprovided with any appendages for grasping food—nutritive particles being brought to it by means of ciliary currents. Numerous muscles exist which connect the valves of the shell to one another, and with the inclosed animal. And, though the visceral organization of the brachiopods is somewhat complex, no definite sense-organs have yet been detected in any of them. In the nervous system of these sedentary animals, there is, therefore, nothing answering to a brain as it is ordinarily constituted,

though ganglia exist around the œsophagus which must receive afferent impressions of some kind, and from which branches proceed to the various muscles and viscera of the body.

Such low sensory endowments as are presented by the ***Brachiopoda*** would be wholly incompatible with that degree of visceral complexity of organization which they possess, had it not been for the fact that they lead such a passive existence in respect to quest of food. They do not go in search of it at all—they remain securely anchored while food is brought to the entrance of their alimentary canal by means of cilia. The absence of sense-organs and of a brain is, indeed, only compatible with a *quasi*-vegetative existence such as this.

The lamellibranchs, or ordinary headless bivalve ***Mollusca***, also include some representatives—such as the oyster and its allies—which lead a sedentary life after the fashion of the ***Mollusca*** already mentioned. The valves of the shell in these lamellibranchs are lateral, instead of being dorsal and ventral as among the branchiopods. The shell is, however, closed by a single adductor muscle, and it is opened, when this relaxes, by means of an elastic hinge.

The mouth of the oyster is surrounded by four labial appendages, whose functions are not very definitely known. It presents no other appendages of any kind in the neighborhood of the mouth, and, as in the two types of ***Mollusca*** already described, the food which it swallows is brought to the entrance of its œsophagus by means of ciliary currents. This well-known animal has a large and important nervous ganglion (Fig. 8, *b*) situated posteriorly, and close to the great ad ductor muscle. It gives off branches to this muscle, to each half of the mantle, to the gills (*c*, *c*), and it sends forward two long parallel branches (*d*, *d*), which serve to connect it with a much smaller anterior ganglion (*a*, *a*) situated on each side of the mouth. These anterior or labial ganglia are joined by a commissure arching over the mouth, and also by a more slender thread beneath the mouth, from which filaments (*e*) are given off to the stomach. These latter filaments may be considered to have a function similar to that of the stomatogastric nerves in insects. The anterior ganglia receive nerves (*f*) from the labial processes, probably for the most part afferent in function. At all events, these processes have no distinct muscular structure.

Other lamellibranchs possess a remarkable muscular appendage known as the foot, which is in relation with an additional single or double nervous ganglion, and is used in various ways as an organ of locomotion. The animals possessing this organ are also provided with a second adductor muscle for closing their shells. Speaking of the various uses of the foot among bivalves, Prof. Owen says: "To some which rise to the surface of the water it acts, by its expansion, as a float; to others it serves by its bent form as an instrument to drag them along the sands; to a third family it is a burrowing organ; to many it aids in the execution of short leaps."

These bivalves possessing a foot present three pairs of ganglia instead of two—the anterior or oval, the posterior or branchial, and the inferior or pedal. It occasionally happens, however, that the ganglia of the posterior or of the inferior pair become approximated or even fused into one. The fusion of the posterior pair takes place, as in the oyster, when the branchiæ from which they receive nerves come close together posteriorly. On the other hand, in those mollusks in which the branchiæ are farther apart, the two ganglia remain separate, and are connected only by a short commissure, as in the mussel (Fig. 9, *b*).

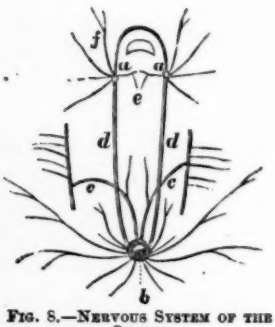


FIG. 8.—NERVOUS SYSTEM OF THE OYSTER.

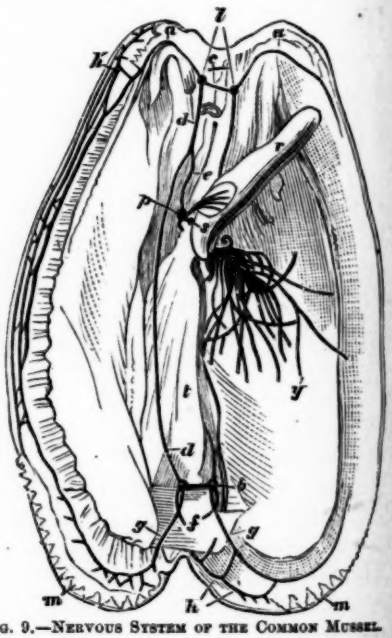


FIG. 9.—NERVOUS SYSTEM OF THE COMMON MUSSEL.

The separate existence or fusion of the inferior or pedal ganglia depends upon the size and shape of the foot. The nerves in relation with these ganglia are distributed almost wholly to this organ and its retractor muscles. Where the foot is broad the ganglia remain separate, and are merely connected by a commissure. But where the foot is small and narrow, as in the mussel, the two ganglia become fused into one (Fig. 9, *p*).

Some of the special senses are unquestionably represented among these headless *Mollusca*, though the distribution of the different organs is very peculiar. Thus in *Pecten*, *Pinna*, *Spondulus*, the oyster, and many others, very distinct and often pedunculated ocelli are distributed over both margins of the pallium or mantle. These vary in number from forty to two hundred or more, and are in connection with distinct branches of the circumpallial nerves. In the razor-fish,

the cockle, Venus, and other bivalves possessing those prolongations of the mantle known as siphon-tubes, the eyes are situated either at the base or on the tips of the numerous small tentacles distributed around the orifices of these tubes, which in those of them living in the sand are often the only parts appearing above the surface. The margins of the mantle are also garnished by a number of short though apparently very sensitive tentacles, in which the creature's most specialized sense of touch seems to reside. Some of these tactile appendages, as well as some of the ocelli, send their nerves to the posterior or parieto-splanchnic ganglia, while those situated on the anterior borders of the mantle communicate with the anterior or oral ganglia. The latter ganglia also receive filaments from the so-called labial appendages, whose function is uncertain, though it has been suggested that they may be organs of taste or smell. Lastly, in close relation with the pedal ganglia or ganglion, there are two minute saccules (Fig. 9, *s*), to which an auditory function is usually ascribed.

Thus we find among these headless mollusks a distribution of specially impressible parts or sensory organs, such as cannot be paralleled among any other animals. The sense of touch and the sense of sight seem to be more especially in relation with the great posterior ganglia. These sensory functions are, however, to a minor extent shared by the oral ganglia, which are also in relation with parts that may possibly be organs of taste or smell. On the other hand, auditory impressions are invariably brought into relation with the inferior or pedal ganglia. In these headless mollusks, therefore, the functions pertaining to the brain in other animals are distributed in a very remarkable manner, and the anterior ganglia cannot in them be properly regarded as representing such an organ.

The viscera in these lamellibranchs are also in relation with the three pairs of ganglia, and not exclusively with any one of them. Filaments to the intestinal canal and the liver are usually given off from the commissures between the anterior and the posterior ganglia; the genital organs are in connection with filaments coming from the commissures between the anterior and the inferior or pedal ganglia; while the branchiæ are in relation with the ganglia at the posterior part of the body.[1]

There is another interesting class of mollusks—the *Pteropoda*—which, in respect of powers of locomotion and the possession of a distinct head, may, if for no other reasons, be said to lead us on from the comparatively sluggish bivalve *Mollusca* to the gasteropods and the cephalopods, all of which are distinguished by definite and wide-reaching powers of locomotion, and by the possession of a distinct head carrying sense-organs, and a more or less developed brain.

[1] In speaking of the nervous system of the lamellibranchs, I have not alluded to certain small accessory ganglia which exist in some of them in relation with peculiar specially developed contractile structures.

The possession, by many members of this class, of two fin-like muscular expansions attached to the side of the head induced Cuvier to give them the name *Pteropoda*. Prof. Owen says: "All the species of *Pteropoda* are of small size; they float in the open sea, often at great distances from any shore, and serve, with the *Acalephæ*, to people the remote tracts of the ocean. In the latitudes suitable to their well-being, the little *Pteropoda* swarm in incredible numbers, so as to discolor the surface of the sea for leagues; and the *Clio* and the *Limacina* constitute, in the northern seas, the principal article of food of the great whales."

Some of the least highly-organized members of this class, such as the *Hyalaceæ*, are provided with a bivalve shell, and cannot be said to possess a head. They have a simple commencement of the alimentary canal at the anterior extremity of the body; but since this anterior extremity has no tactile appendages and no eyes, and inasmuch as it also contains no cerebral ganglia, it can have no claim to be considered as a head. Their chief nervous centre consists of a flat, somewhat quadrate, sub-œsophageal ganglion, to the anterior angles of which is attached a nervous commissure which extends upward so as to encircle the gullet, though there are no ganglia either on or at the sides of this tube in the usual situation occupied by cerebral ganglia.

In other pteropods devoid of a shell, we meet with a higher organization. Thus in *Clio* there is a distinct head bearing sensory appendages in the form of two tentacula and two eyes, and containing in its interior a brain. This brain is represented by two connected super-œsophageal ganglia, which are in relation, by means of nerves, with the cephalic sensory organs, and in connection with the sub-œsophageal commissure are the two pedal and two branchial ganglia. The two pairs of ganglia exist separately in *Clio* and its allies, though they are combined into one quadrate mass in *Hyalea*. In this latter there are two acoustic vesicles in contact with the anterior part of the great ganglion, while in *Clio* similar vesicles are in connection with the anterior pair of sub-œsophageal ganglia—that is, with the pair which corresponds with the pedal ganglia of the common bivalve mollusks.

Gasteropods constitute a class of organisms which, in point of numbers, can only be compared with the still more numerously represented class of insects. Their name is derived from the fact that these animals crawl by means of a large muscular expansion stretched out beneath the viscera. The locomotion of the members of this class may be said to be, in the main, dependent upon their own individual efforts, so that, in this respect, they differ widely from the pteropods, whose locomotions are brought about by winds driving them along the surface of the water on which they float.

Some gasteropods are terrestrial, air-breathing animals, though by

far the greater number are aquatic, and breathe by means of gills. But being all of them, as Prof. Owen says, "endowed with power to attain, subdue, and devour organic matter, dead and living," we find their nervous system not only better developed, more complex and concentrated, but also in relation with more highly-evolved organs of special sense and exploration. It offers considerable variations in its general arrangement, especially as regards relative positions of ganglia, though these modifications are, to a great extent, referable to differences in the outward configuration of the body.

Some of the differences in external form which are to be met with among gasteropods are well illustrated by the limpet or the chiton, as compared with the snail. Here differences in form coexist with differences in habit, so that we almost necessarily meet with notable variations in the disposition of the principal parts of the nervous system.

In the limpet we find that the two small cerebral ganglia (Fig. 10, *a*) are widely separated from one another, and lie at the side of the œsophagus. Each receives a rather large nerve from one of the tentacles, and a smaller optic nerve. A commissure connects these cerebral ganglia above the œsophagus with one another, while each of them is also in relation by means of two descending commissures with a series of four connected ganglia forming a transversely-arranged row beneath the œsophagus. Of these the two median ganglia (*B*) correspond with the pedal, while the two external (*C*) correspond with the branchial ganglia, though they are here separated from one another by an immensely wide interval.

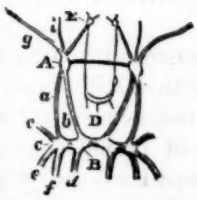


FIG. 10.—NERVOUS SYSTEM OF THE COMMON LIMPET.

FIG. 11.—NERVOUS SYSTEM OF *Chiton marmoratus*.

However small and undeveloped the duplex brain of the limpet may be, this organ exists in an even more rudimentary state in some other gasteropods. Thus, in the chiton, which is a close ally of the limpet, and about the most simply organized of all the gasteropods, there are neither tentacles nor eyes, and, as a consequence of this,

there are (Fig. 11) no supra-œsophageal ganglia. There is nothing, in fact, to which the term brain can be appropriately applied.

But, if we turn now to the much more active snail, we find the nervous system existing in a more developed and concentrated form. There is (Fig. 12, *l*) a large ganglionic mass situated over the œsophagus, each half of which receives a considerable bundle of nerve-fibres (*f*) from the eye (*b*) of the smaller side, which is situated at the tip of the larger tentacle. It also receives another bundle of nerves (*k*)

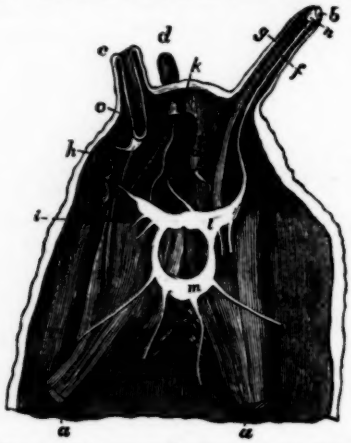


FIG 12.—HEAD AND NERVOUS SYSTEM OF THE COMMON SNAIL.

from the small tentacle on each side, which has in all probability a tactile function. The auditory vesicles are here in a new position. They are in immediate relation with the posterior aspect of these ganglia constituting the brain, though in other gasteropods they are, as in bivalve *Mollusca*, found to be connected with the pedal ganglia. That gasteropods are endowed with a rudimentary sense of smell is now generally admitted by naturalists, though hitherto they have been unable to locate this endowment in any particular organ or surface-region.

The brain of the snail is connected, by means of a triple cord or commissure on each side of the œsophagus, with a still longer double ganglionic mass (*m*). This latter body, situated beneath the œsophagus, represents the pair of pedal and the pair of branchial ganglia of the bivalve *Mollusca*. Here nerves are received from the integument and given off to the muscles of the foot, while they are also received and given off from the respiratory and other organs.

In the nautilus and some other representatives of the next class, *Cephalopoda*, the nervous system attains a development only slightly in advance of that met with among the highest gasteropods, though in the active and predaceous cuttle-fish, and in its near ally, the octopus, we find the nervous system presenting the highest development to be met with among the sub-kingdom *Mollusca*.

One of the most striking characteristics of the principal nerve-centres of the cuttle-fish is the fact of the existence of a very large optic ganglion (Fig. 13, 2), in connection with a well-developed eye, on each side. Each optic lobe, according to Lockhart Clarke, is "as large as the rest of the cephalic ganglia on both sides taken together." From each of these lobes an optic peduncle passes inward to join a supra-œsophageal ganglionic mass, which bears on its surface a large bilobed ganglion (1), thought by Clarke to be homologous with the cerebral lobes of fishes. It is connected, by means of two short cords,

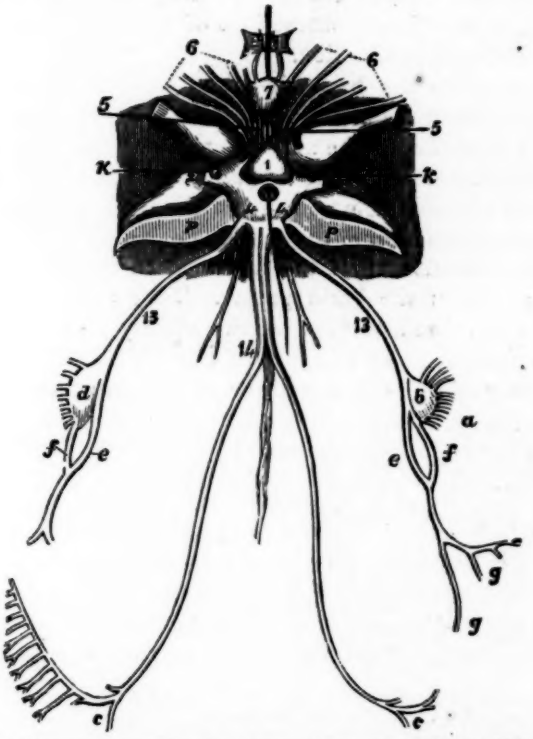


FIG. 13.—NERVOUS SYSTEM OF THE COMMON CUTTLE-FISH (*Sepia officinalis*).

with a much smaller bilobed ganglion, known as the pharyngeal (7). This double ganglion receives nerves from what are presumed to be the organs of taste and smell, and gives off nerves to the tongue and powerful parrot-like jaws with which the creature is provided.

The supra-œsophageal mass is connected, by cords at the sides of the œsophagus, with a very large ganglion lying beneath it (4), which is partially divided into an anterior and a posterior division. The anterior division is in relation, by means of large nerves (6), with the feet and tentacles. A commissure also unites it with the pharyngeal ganglion, so that the tentacles and arms are thus able to be brought

into correlated action with the jaws. The posterior portion of the sub-œsophageal mass receives nerves from, and also gives off nerves (14) to, the branchiæ and other viscera, as well as to the mantle (13, 13).

The auditory organs and their nerves are also connected with this branchial and pallial ganglion. These organs are lodged in the substance of the cartilaginous framework investing the nerve-ganglia—a structure which seems to answer to a rudimentary skull. The roots of the auditory nerves are probably principally in relation with the pallial portion of the branchio-pallial ganglion. The locomotions of these creatures are largely brought about by contractions of the pallial chamber, though these contractions of the mantle are also subservient to the respiratory function.

The share which the branchio-pallial ganglia take in bringing about and regulating the movements of the cuttle-fish would seem to explain the connection of the auditory nerves with them rather than with the homologues of the pedal ganglion, with which the auditory saccules are in relation in most other mollusks. But, whatever may be the precise explanation of the different connections of the auditory nerves in the cuttle-fish tribe, the fact remains that their connections are still away from the brain proper. They are, as in most other *Mollusca* and in those insects in which auditory organs are known to occur, in intimate relation with one of the principal motor centres.

This survey of some of the principal forms of the invertebrate brain, brief though it has been, should have sufficed to call attention to the following important facts and inferences:

1. That sedentary animals, though they may possess a nervous system, are often headless, and then have nothing answering to a brain.

2. That where a brain does exist, it is invariably a double organ. Its two halves may be widely separated from one another, though at other times they are fused into a single mass.

3. That the component or elementary parts of the brain in these lower animals are ganglia in connection with some of those special impressible parts or sense-organs, by means of which the animal is brought into harmony with its environment or medium.

4. That the sensory ganglia, which as an aggregate constitute the brain of invertebrate animals, are connected with one another both on the same and on opposite sides of the body, either by continuous growth or by means of commissures.

5. The size of the brain as a whole, or of its several parts, is strictly regulated by the development of the animal's special sense-organs. This is so, because, the more these impressible surfaces become elaborated and attuned to help in discriminating between numerous different external impressions, the larger are the ganglionic masses with which their nerves are in relation.

6. Of the several sense-organs and sensory ganglia whose activity

lies at the root of the intellectual and instinctive life (such as it is) of invertebrate animals, some are much more important than others. Two are notable for their greater proportional development, viz., tactile organs and visual organs. The former are soon outstripped in importance by the latter. The visual sense, indeed, and its related nerve-ganglia, attain an altogether exceptional development in the higher insects and mollusks.

7. The sense of taste and that of smell are developed to a much lower extent. It is even difficult to point to distinct organs or impressible surfaces as certainly devoted to the reception of impressions of this kind.

8. The sense of hearing is also developed to a very slight extent. No distinct sense-organ of this kind has been discovered, except in a few insects and in members of the sub-kingdom *Mollusca* It is, however, of no small interest to find that, where these organs do exist, the nerves issuing from them are not in direct relation with the brain, but are immediately connected with one of the principal locomotor nerve-centres of the body.

9. The associated ganglia representing the single or double brain are, in animals possessing a head, the centres in which all impressions from sense-organs, save those last mentioned (the auditory), are reflected on to appropriate groups of muscles. This reflection occurs either at once or after the stimulus has passed through other ganglia, whence it is passed along nerves to those groups or combinations of muscles whose simultaneous or successive contractions give rise to the organism's reply to such impressions. It may be easily understood, therefore, that in all such animals perfection of sense-organs, size of brain, and power of executing varied muscular movements, are intimately related to one another.

10. But a fairly parallel correlation also becomes established between these various developments and that of the internal organs. An increasing visceral complexity is gradually attained. Such increased visceral complexity carries with it the necessity for a further development of nervous communications. The several internal organs have to be brought into more perfect relation with the sensori-motor nervous system, and also with one another, for all joint actions in which two or more of them may be concerned.

11. In invertebrate animals the visceral system of nerves has, when compared with the rest of the nervous system, a greater proportional development than among vertebrate animals. Its importance among the *Invertebrata* is not dwarfed by the enormous development of the brain and spinal cord, which gradually declares itself among the *Vertebrata*.

12. Impressions emanating from the viscera and stimulating the organism to movements of various kinds, whether in pursuit of food or of a mate, would, therefore, have a proportionally greater impor-

tance as constituting part of the ordinary mental life of invertebrate animals. Movements thus initiated will be found to afford a basis for the development of many so-called instinctive acts.

PRENATAL AND INFANTILE CULTURE.[1]

By Dr. E. SEGUIN.

TO educate children for themselves is rare in Europe, and is considered rather quixotic. The youth of the people are merchantable commodities, soon to be credited to the party which puts its stamp upon them. Therefore, when they are worth having, they are picked up as eagerly as nuggets. Priests pretend to teach them to think, yet care only to impose upon them a belief which implies obedience to their craft; Kaisers claim their direction, not to elevate them, but to put them among their droves of subjects; *bourgeois* and manufacturers give them a minimum of instruction, just sufficient to insure their working dependence, and to qualify their own sons to be fed at the public expense; while the working-men themselves—demoralized by such examples—put their apprentices at menial employment, and cheat them out of their rightful technical training.

From this standpoint we consider European children as in four groups: those who receive no education; those who do not receive the education they need; those who receive an education which disqualifies them for work; and those whose education prepares them for work. From another point of view we saw that the European children enter the school younger, are trained longer, and are advanced further, than the Americans. As a consequence of this last contrast, we shall have less to say about the primary and grammar schools, and more about the infantile and the professional. We will leave the other consequences to issue naturally from observation.

1. The Cradle.—At the Vienna Exposition there was a *pavillon de l'enfant* (infant pavilion), a room replete with the necessaries of the nursery—and also with its superfluities—intended altogether to represent the unbounded wishes of a mother for her baby's comfort and happiness. This palace of luxurious nursing ought, in the estimation of the writer, to have been accompanied by a little manual of what is necessary to protect and to prepare life before nativity, in relation to what may be called fœtal education.

During this first period the feelings come mainly through reflex impressions from the mother, a process which not only lays the foundation of health and vitality, but which forms the deeper strata of

[1] Extracts from the Report of the Commissioners of the United States to the International Exhibition held at Vienna, 1873.

the moral dispositions and of the so-called innate ideas. The managers of the world "from behind the screens" know this, for it is at this time that they impose on plebeian women pilgrimages and ecstatic "*novenas*,"[1] and keep those of a higher class under more stringent impressions. Here, in Vienna, for instance, from the time of the Emperor Charles V. till quite recently, when an heir to the throne was expected, the empress was given in charge of a special director, who would regulate all her actions and surroundings, in view of commencing the course of submissive education of the contingent monarch, as early as the first evolution from the yolk-substance of the human egg during embryogenesis. Similar influence is now claimed for an object diametrically opposed to the degeneracy thus arrived at in the house of Hapsburg. It can be attained by counsels printed either in book-form or on scrolls, as are the sentences of the Koran. But, whatever may be the form given to this *magna charta* of the rights of the unborn, let it be found precisely where these rights ought to be kept most sacred, in the nursery; where their enforcement would protect the mother and elevate her function, at the same time that it would insure her fruit against the decay resulting from wrong prenatal impressions.

We know that a cold contact with the mother makes the fœtus fly to the antipode of its narrow berth; that a rude shock may destroy it, or originate life-long infirmities; that the emotion of fear in the mother is terror or fits within; that harsh words vibrate as sensibly in the liquor of the amnion as in the fluid of the labyrinth of the ear. For instance, when a mother has lulled her home-sorrows with strains of soothing music, her child, too often an idiot, shows wonderful musical proclivities amid the wreck of all the other faculties of his mind. For thirty-five years the writer has furnished his share of the facts, which abound in modern books on physiology, in support of this doctrine.

It is useless to give here the illustrations detailed in the report; but experienced physicians will testify that, when their hands receive a new-comer, they plainly read upon his features the dominant feelings and emotions of its mother during that intra-uterine education whose imprints trace the channel of future sympathies and abilities. Therefore, if it is noble work to educate or to cure the insane, the idiot, the hemiplegic, the epileptic, and the choreic, how much higher is the work of preventing these degeneracies in the incipient being, by averting those commotions which storm him in the holy region intended for a terrestrial paradise during the period of evolution! To teach *him* reverence toward the bearer of his race, to instruct *her* in the sacredness of bland and serene feelings during the Godlike creative process, is educating two generations at once—this is the highest education of the nursery.

[1] A nine days' season of prayer.

From this, the true cradle of mankind, let us look at that made for the baby. There was no end of cradles in the *pavillon de l'enfant;* and we may find more philosophy in them than the upholsterer intended to put there. Therein the infant will at first but continue his ovum-life; and for this the cradle must be fitted. Let us see. The head is bent, the extremities are drawn up, and the body shaped like a crescent. This attitude gives to the muscles the greatest relaxation, and to the cartilages, which cap the bones, the position most favorable to nutrition and growth. Generally, the baby rests on the right side, to free the heart from pressure and to facilitate its movements. In this mode of reclining, the left hemi-cerebrum will contain more blood than the right, which is compressed by the pillow. Attitudes concordant with the sleepy habits of the first months, and the activity of the mind during this long sleepiness, indicate the future preponderance of the mental operations of the left over the right side of the brain, the approaching superior nutrition and dexterity of the right over the left hand, and later even the causation of paralysis on the left. For the present, and for some time yet, the infant will live mainly in his sleep; during which, more than when awake, he will be seen angry, smiling, or thinking, even in his well-defined dreams.

How important it is, then, that the cradle be formed in accordance with these natural indications! A transitory abode between the basin and the bed, it should be a warm, soft, yet supporting recipient, ampler than the former, better defined in its shape than the latter, with curves less short than circles, and more varied than ovals. An egg, vertically split, would make two such cradles, or nests, suited either for child or bird.

But as soon as the nursling awakes to the world, and wants to be introduced to everything, his couch must be enlarged and enlivened, and must look more and more like a school and play-room. Otherwise it becomes a prison, whence, Tantalus-like, baby looks at his surroundings. Here is his first lesson of practical sociability. To see, and not be able to reach, to perceive images, with no possibility of seizing the objects, renders him impatient, fretful, or unconcerned, and opens an era of exaction upon others, or of diffidence of himself, or of indifference for any attainment, which unavoidably ends in immorality or incapacity, or in both. Viewed from this standpoint, these cradles, so varied, so elegant, so easy to keep clean, and to carry from the light of the window by day to the recess of the alcove at night—the best being of French and Austrian manufacture—are yet very imperfect in their bearing on education. Let us mark some of their shortcomings.

Little ones have an instinctive horror of isolation. Whoever studies them knows that when they awake they look not, at first, with staring eyes, but with searching hands; they seek not for sights, but for contacts. This love of contact, whence results the primary

education of the most general sense, the touch, is ill-satisfied with the uniformity of the materials at hand, as exemplified at Vienna or Paris. (In November last I saw a similar exhibition, a *pavillon de l'enfant*, in the Champs Élysées, but it was no improvement on that of the Prater.)

In this respect, the child of poor people fares better, having the opportunity of amusing himself for hours in experiencing the rude or soft, warm or cold, contacts of his miscellaneous surroundings; whereas the hand of the offspring of the rich finds all around the sameness of smooth tissues, which awake in his mind no curiosity; he calls for some one to amuse him, gets first angry, then indifferent, and does not improve the main and surest sense of knowledge, his touch.

But soon other senses are awakened: audition—of which hereafter—and vision, for the enjoyment of which the cradle becomes a kind of theatre. For a mother must be very destitute or despondent who does not try to enliven it with some bright things laid on, or flapping above. One may benevolently smile at the extravagancies of colors and patterns intended to express this feeling, but these exaggerations must also give a serious warning.

Physiologically viewed, this is a grave matter. The form of the cradle demands fitness; its ornamentation requires a more extended knowledge. When planning it, a mother must remember that the fixity of the eye upon any object—particularly upon a bright one, and more so if that object is situated upward and sideways from the ordinary range of vision—and through the eye the fixedness of the mind while the body is in a state of repose, constitute a concurrence of conditions eminently favorable to the production of hypnotism, and its terrible sequels, strabismus and convulsions. Hypnotism, which, when unsuspected, is not controlled, is often mistaken for tranquil happiness or natural sleep.

Psychologically viewed, the decoration of the cradle is of equal moment. To surround an infant with highly wrought or colored figures, often grotesque, or at least untrue to Nature, may, by day, attract more attention than his faculties of perception can safely bestow; hence fatigue of the brain, or worse; but it will, by night, evoke other than the perceptive and rational powers, for, when the lights and shadows of dusk alter all the forms and deepen every color, the faculty of imprinting images being led astray, it photographs distorted imprints from confused, often moving, sometimes rustling, ornaments. In this way the mind is made the subject of hallucinations, which it accepts as objective, without inquiring into their causes, till it comes to the fatal *credo quia absurdum* (I believe, because it is absurd). The seeds of most of the insanities are sown at or before this time.

These were the first impressions that forced themselves upon my

mind in the *pavillon de l'enfant*. Here is, in a few words, a *résumé* of them: Paucity of the material upon which the inexperienced yet inquisitive baby can exercise, with interest and profit, his sense of touch; profusion, bad taste, and dangerous disposition of the objects which speak to the eye, if not always with the intention, at least with the almost uniform result, of giving wrong or dangerous impressions.

Attention was next called to what had been done, and to what had been left undone, for the cultivation or the satisfaction of the other senses of the infant. But here it was soon perceived that our inquiries went beyond the sphere of what was exhibited. There were plenty of Farina's and Rimmel's volatilities, some of Alexander's, Debain's, or Smith's sighing accordeons, but no means of cheering and educating the nascent yet already inquisitive senses. Further examination showed that the perfumes were there as an attenuation and the music as a distraction, and both intended for other senses than the infant's. From these and other omissions it was concluded that nursery arrangements are as yet intended rather for the mother's and nurse's comfort than for the baby's improvement.

2. THE CRÈCHE.—This *pavillon de l'enfant* ought to contain at least ene model *crèche*.

Crèche is the French name of the public nursery where working-women leave their little ones in the morning, and whence they bring them home at night. The *crèche!* Horrid necessity! Beginning of the communistic inclined plane upon which those who pay and do not receive rents slide with a fearful rapidity; yet a kind institution for those already fallen into the gulf. Since, therefore, *crèches* must be, their latest improvements should have been represented at the Vienna Exhibition next to the appliances of the most luxurious nursing. There could have been tested the action of colors, of light, and its various attributes, on the organ of vision; the influence of varied sounds, of harmonies and melodies on the virgin audition, the mind, and the sympathetic centres; the power of primary perceptions to awaken first ideas, to impel to determinations of the will, and to raise or calm the various passions; the effects of diet upon those passions; the effect of modification of food and digestion; the influence of rest and sleep on the body's temperature, on the pulse and respiration; the influence of the artificial, the moist, or the dry heat of the nursery on the too precocious development of the nervous centres, and, subsequently, on the prevalence of chronic or acute meningitis, diphtheria, and croup; besides many other problems whose solution depends on the early study of phenomena which can be found in the *crèche* as surely as the flower in the bud. There, better than anywhere else, they may be studied with profit to all parties. Let us bear in mind that the rich man can never flatter himself that he does a gratuitous charity, since from its poor recipient comes many

times its worth in useful experience, directly benefiting the would-be benefactor. We do not overlook the fact that many mothers, particularly among those both educated and fruitful, pay the closest attention to these questions, and become expert therein, but, as they lack the means of record and transmission of their observations, their experience dies, so to speak, with each generation. Hence the nursing of babies continues to be a work of devotion, but does not become the coördinated and progressive art it ought to be in well-organized *crèches* open to criticism in public exhibitions. Thus in Vienna, at least, an opportunity was lost.

PROFESSOR HUXLEY'S LECTURES.[1]

I.

THE THREE HYPOTHESES OF THE HISTORY OF NATURE.

WE live and form part of a system of things of immense diversity and perplexity, which we call Nature, and it is a matter of the deepest interest to all of us that we should form just conceptions of the constitution of that system and of its past history. With relation to this universe, man is, in extent, little more than a mathematical point; in duration, but a fleeting shadow. He is a reed shaken in the winds of force; but, as Pascal long ago remarked, although a reed, he is a thinking reed, and, in virtue of that wonderful capacity of thought, he has a power of framing to himself a symbolic conception of the universe, which, although doubtless highly imperfect, and although wholly inadequate as a picture of that great whole, is yet sufficient to serve him as a guide-book in his practical affairs. It has taken long ages of accumulated and often fruitless labor to enable man to look steadily at the shifting scenes, phantasmagoria of Nature, to notice what is fixed among her fluctuations, and what is regular among her apparent irregularities; and it is only comparatively lately, within the last few centuries, that there has emerged the conception of a pervading order and a definite course of things, which we term the course of Nature.

But out of this contemplation of Nature, and out of man's thought concerning her, there has in these later times arisen that conception of the constancy of Nature to which I have referred, and which at length has become the guiding conception of modern thought. It has ceased to be almost conceivable to any person who is familiar with

[1] The first of three lectures on "The Direct Evidence of Evolution," delivered at Chickering Hall, New York, September 18th. From the report of the *New York Tribune*, carefully revised by Prof. Huxley.

the facts upon which that conception is based, that chance should have any place in the universe, or that events should follow anything but the natural order of cause and effect. We have come to look upon the present as the child of the past and as the parent of the future; and, as we have excluded chance from any share or part in the order of things, so in the present order of Nature men have come to neglect, even as a possibility, the notion of any interference with that order. And, whatever may be men's speculative notions upon those points, it is quite certain that every intelligent person guides his life and risks his fortune upon the belief that the order of Nature is constant, and the relation of cause to effect unchanged.

In fact, there is no belief which we entertain which has so complete a logical basis as that to which I have just referred. It tacitly underlies every process of reasoning; it is the foundation of every act of the will. It is based upon the broadest induction, and it is verified by the most constant, regular, and universal of deductive processes. But we must recollect that any human belief, however broad its basis, however defensible it may seem, is, after all, only a probable belief, and that our broadest generalizations are simply statements of the highest degrees of probability. Though we are quite clear about the constancy of Nature at the present time, and in the present order of things, it by no means follows necessarily that we are justified in expanding this generalization into the past, and in denying absolutely that there may have been a time when Nature did not follow a fixed order, when the relations of cause and effect were not definite, and when external agencies did not intervene in the general course of Nature. Cautious men will admit that such a change in the order of Nature may have been possible, just as a very candid thinker may admit that there may be a world in which two and two do not make four, and in which two straight lines do not inclose a space. In fact, this question with which I have to deal in the three lectures I shall have the honor of delivering before you, this question as to the past order of Nature, is essentially an historical question, and it is one that must be dealt with in the same way as any other historical problem.

I will, if you please, in the first place, state to you what are the views which have been entertained respecting the order of Nature in the past, and then I will consider what evidence is in our possession bearing upon these views, and by what light of criticism that evidence is to be interpreted. So far as I know, there are only three hypotheses which ever have been entertained, or which well can be entertained, respecting the past history of Nature.

Upon the first of these the assumption is, that the order of Nature which now obtains has always obtained; in other words, that the present course of Nature, the present order of things, has existed from all eternity. The second hypothesis is, that the present state of

things has had only a limited duration, and that at some period in the past the state of things which we now know (substantially, though not, of course, in all its details) arose and came into existence without any precedent condition from which it could have naturally proceeded. The third hypothesis also assumes that the present order of Nature has had but a limited duration, but it supposes that the present order of things proceeded by a natural process from an antecedent order, and that from another antecedent order, and so on; and on this hypothesis the attempt to fix any limit at which we could assign the commencement of this series of changes is given up. I am very anxious that you shall realize what these three hypotheses actually mean; that is to say, what they involve, if you can imagine a spectator to have been present during the period to which they refer. On the first hypothesis, however far back in time you place that spectator, he would have seen a world essentially, though not perhaps in all its details, similar to that which now exists. The animals which existed would be the ancestors of those which now exist, and like them; the plants in like manner would be such as we have now; and the supposition is that, at however distant a period of time you place your observer, he would still find mountains, plains, and waters, with animal and vegetable products flourishing upon them and sporting in them just as he finds now. That view has been held. It was a favorite fancy of antiquity, and has survived toward the present day. It is worthy of remark that it is an hypothesis which is not inconsistent with what geologists are familiar with as the doctrine of Uniformitarianism. That doctrine was held by Hutton, and in his earlier days by Lyell. For Hutton was struck with the demonstration of astronomers that the perturbations of the planetary bodies, however great they may be, yet sooner or later right themselves, and that the solar system contained within itself a self-adjusting power by which these aberrations were all brought back to an equilibrium.

Hutton imagined that something of the same kind may go on in the earth, although no one recognized more clearly than he the fact that the dry land is being constantly washed down by rain and rivers and deposited in the sea, and that thus in a certain length of time, greater or shorter, the inequalities of the earth's surface must be leveled, and its high lands brought down to the sea. Then, taking into account the internal forces of Nature, by which upheavals of the sea-bottom give rise to new land, he thought that these operations might naturally compensate each other, and thus, for any assignable time, the general features of the earth might remain what they are. And, inasmuch as there need be no limit under these circumstances to the propagation of animals and plants, it is clear that the logical development of this idea might lead to the conception of the eternity of the world. Not that I mean to say that either Hutton or Lyell held this conception—assuredly not; they would have been the first to repu-

diate it. But, by the arguments they used, it might have been possible to justify this hypothesis.

The second hypothesis is that to which I have referred as the hypothesis which supposes that the present order of things had at some no very remote time a sudden origin, so that the world, such as it now is, arose. That is the doctrine which you will find stated most fully and clearly in the immortal poem of John Milton, the English "Divina Commedia," "Paradise Lost." I believe it is largely to the influence of that remarkable work, combined with daily teachings to which we have all listened in our childhood, that this hypothesis owes its general wide diffusion as one of the current beliefs of English-speaking people. If you turn to the seventh book of "Paradise Lost" you will find there stated the hypothesis to which I refer, which is briefly this: That this visible universe of ours made its appearance at no great distance of time from the present day, and that the parts of which it is composed made their appearance in a certain definite order in the space of six natural days, in such a manner that in the first of these days light appeared; in the second, the firmament or sky separated the water above from the water beneath it; on the third day the waters drew away from the dry land, and upon it a varied vegetable life similar to that which now exists made its appearance; that the fourth day was devoted to the apparition of the sun, the stars, the moon, and the planets; that on the fifth day aquatic animals originated within the waters; that on the sixth day the earth gave rise to our four-footed terrestrial creatures, and to all varieties of terrestrial animals except birds, which had appeared on the preceding day; and, finally, that man appeared upon the earth, and the work of fashioning the universe was finished. John Milton, as I have said, leaves no doubt whatever as to how, in his judgment, these marvelous processes occurred. I doubt not that his immortal poem is familiar to all of you, but I should like to recall one passage to your minds, in order that I may be justified in what I have said regarding the perfectly concrete, definite conception which Milton had respecting the origin of the animal world. He says:

"The sixth, and of creation last, arose
With evening harps and matin; when God said,
'Let the earth bring forth soul living in her kind,
Cattle and creeping things, and beast of the earth,
Each in their kind.' The earth obeyed, and straight
Opening her fertile womb, teemed at a birth
Innumerous living creatures, perfect forms,
Limbed and full-grown; out of the ground uprose,
As from his lair, the wild beast, where he wons
In forest wild, in thicket, brake, or den;
Among the trees in pairs they rose, and walked;
The cattle in the fields and meadows green;
Those rare and solitary, these in flocks

Pasturing at once, and in broad heards upsprung.
The grassy clods now calved; now half appears
The tawny lion, pawing to get free
His hinder parts, then springs, as broke from bonds,
And rampant shakes his brinded mane; the ounce,
The libbard, and the tiger, as the mole
Rising, the crumbled earth above them threw
In hillocks; the swift stag from underground
Bore up his branching head; scarce from his mould
Behemoth, biggest born of earth, upheaved
His vastness; fleeced the flocks and bleating rose
As plants; ambiguous between sea and land,
The river-horse and scaly crocodile.
At once came forth whatever creeps the ground,
Insect or worm."

There is no doubt as to the meaning of this statement, or as to what a man of Milton's genius expected would have been actually visible to one who could witness the process of the origination of living things.

The third hypothesis, or the hypothesis of evolution, supposes that at any given period in the past we should meet with a state of things more or less similar to the present, but less similar in proportion as we go back in time; that the physical form of the earth could be traced back in this way to a condition in which its parts were separated, as little more than a nebulous cloud making part of a whole in which we should find the sun and the other planetary bodies also resolved; and that, if we traced back the animal world and the vegetable world, we should find preceding what now exist animals and plants not identical with them, but like them, only increasing their differences as we go back in time, and at the same time becoming simpler and simpler, until finally we should arrive at that gelatinous mass which, so far as our present knowledge goes, is the common foundation of all life.

The hypothesis of evolution supposes that in all this vast progression there would be no breach of continuity, no point at which we could say "This is a natural process," and "This is not a natural process," but that the whole might be compared to that wonderful series of changes which may be seen going on every day under our eyes, in virtue of which there arises, out of that semifluid, homogeneous substance which we call an egg, the complicated organization of one of the higher animals. That, in a few words, is what is meant by the hypothesis of evolution.

I have already suggested that in dealing with these three hypotheses, in endeavoring to form a judgment as to which of them is the more worthy of belief; or whether none is worthy of belief—and our condition of mind should be that suspension of judgment which is so difficult to all but trained minds—we should be indifferent to all *a*

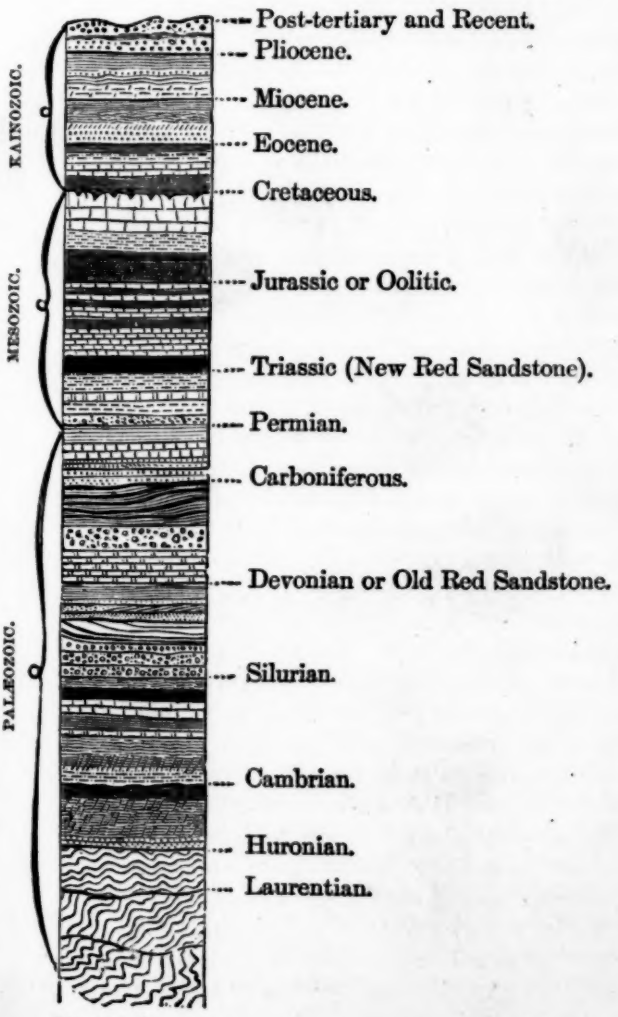
priori considerations. The question is a question of fact, historical fact. The universe has come into existence somehow or other, and the question is, whether it came into existence in one fashion, or whether it came into existence in another; and, as an essential preliminary to our further discussion, permit me to say two or three words as to the nature of historical evidence, and the kinds of historical evidence. The evidence as to the occurrence of any fact in past time is of one or two kinds, which, for convenience' sake, I will speak of on the one hand as testimonial evidence, and on the other as circumstantial evidence. By testimonial evidence I mean human testimony; and by circumstantial evidence I mean evidence which is not human testimony. Let me illustrate by a familiar figure what I mean by these two kinds of evidence, and what is to be said respecting their value:

Suppose that a man tells you that he saw a person strike another and kill him; that is testimonial evidence of the fact of murder. But it is possible to have circumstantial evidence of the fact of murder; that is to say, you may find a man dying with a wound upon his head having exactly the form and character of the wound which is made by an axe, and, with due care to take surrounding circumstances into account, you may conclude with the utmost certainty that the man has been murdered—is dying in consequence of the violence inflicted by that implement. We are very much in the habit of considering circumstantial evidence as of less value than testimonial evidence, and it may be in many cases, where the circumstances are not perfectly clear and perfectly intelligible, that it is a dangerous and uncertain kind of evidence; but it must not be forgotten that in many cases it is quite as good as testimonial evidence, and that not unfrequently it is a great deal better than testimonial evidence. For example, take the case to which I referred just now. The circumstantial evidence is better and more convincing than the testimonial evidence, for it is impossible, under the circumstances that I have mentioned, to suppose that the man had met his death from any cause but the violent blow of an axe wielded by another man. The circumstantial evidence in favor of a murder having been committed, in that case, is as complete and as convincing as evidence can be. It is evidence which is open to no doubt and no falsification. But the testimony of the witness is open to multitudinous doubts. He may have been mistaken. He may have been actuated by malice. It has constantly happened that even an accurate man has declared a thing has happened in this, that, or the other way, when a careful analysis of the circumstantial evidence has shown that it did not happen in that way, but in some other way.

Now we must turn to our three hypotheses. Let me first direct your attention to what is to be said about the hypothesis of the eternity of this state of things in which we now are. What will first strike you is, that that is an hypothesis which, whether true or false, is not capable of verification by evidence; for, in order to secure testi-

mony to an eternity of duration, you must have an eternity of witnesses or an infinity of circumstances, and neither of these is attainable. It is utterly impossible that such evidence should be carried beyond a certain point of time, and all that could be said at most should be that there was nothing to contradict the hypothesis. But when you look, not to the testimonial evidence—which might not be good for much in this case—but to the circumstantial evidence, then you find that this hypothesis is absolutely incompatible with that circumstantial evidence, and the evidence is of so plain and so simple a character that it is impossible in any way to escape from the conclusions which it forces upon us.

IDEAL SECTION OF THE CRUST OF THE EARTH.



You are, doubtless, all aware that the crust of the earth, the superficial part of the earth, is not of an homogeneous character, but that it is made up of a number of beds or strata, the titles or the principal groups of which are placed upon the accompanying diagram—beds of sand, beds of stone, beds of clay, of slate, and of various other materials.

On further examination, it is found that these beds of solid material are of exactly the same nature as these which are at present being formed under known conditions at the surface of the earth; that the chalk, for example, which forms a great part of the Cretaceous formation in some parts of the world, is identical in its physical and chemical characters, or practically so, with a substance which is now being formed at the bottom of the Atlantic Ocean, and covers an enormous area; that other bodies of rock are comparable with the sands which are being formed upon sea-shores, packed together, and so on. Thus it comes to be certain that, omitting rocks of igneous origin, all these beds of stone, of which a total of not less than seventy thousand feet is known, have been deposited and formed by natural agencies, either out of the waste and washing of the dry land, or else as the product of plants and animals. Now, these rocks or strata are full of the remains of animals and plants. Countless thousands of species of animals and plants, as perfectly recognizable as those which you meet with in museums at the present day, or as the shells and remains which you pick up upon the beach—countless thousands of species of these creatures have been imbedded in the sand or mud, or limestone, just as they are being imbedded now. They furnish us with a record, the general nature of which cannot be subject to any misinterpretation, as to the kind of things that have lived upon the surface of the earth during the time that is registered by this great thickness of stratified rock. The most superficial study of these remains shows us that the animals and plants which live at the present time have had only a temporary duration; that you will find them and such as they are now, for the most part, only in those uppermost of the strata called Tertiary. As you go back in time their places are taken by other forms as numerous and diversified, but different, and you will find yet others different from the Cretaceous or Tertiary, and from those of the present day, and so on, as you go further and further back. Thus, the circumstantial evidence absolutely negatives the conception of the eternity of the present condition of things. We can say with certainty that such has not been the course of Nature. We can say with certainty that the present condition of things has existed for a comparatively short period; and that, so far as animal and vegetable nature are concerned, it has been preceded by a different condition of things. We can pursue this evidence until we reach the lowest of stratified rocks, in which we lose the indications of life altogether. The hypothesis of the eternity of the present condition of things may, therefore, be put out of court.

We now come to what I may call Milton's hypothesis—the hypothesis that the present condition of things has endured for a comparatively moderate time, and at the commencement of that time came into existence within the course of six days. I doubt not that it may have excited some surprise in your minds that I should have spoken of this as Milton's hypothesis, rather than that I should choose the terms which are much more familiar to you, such as "the doctrine of creation," or "the Biblical doctrine," or "the doctrine of Moses," all of which denominations, as applied to the hypothesis to which I have just referred, are certainly much more familiar to you than the title of the Miltonic hypothesis. But I have had what I cannot but think are very weighty reasons for taking the course which I have pursued. For example, I have discarded the title of the hypothesis of creation, because my present business is not with the question as to how Nature has originated, as to the causes which have led to her origination, but as to the manner and order of the appearance of natural objects. Our present inquiry is not why the objects which constitute Nature came into existence, but when they came into existence, and in what order. This is a strictly historical question, a question as completely historical as that about the date at which the Angles and the Jutes invaded England. But the other question about creation is a philosophical question, and one which cannot be solved or even approached by the historical method. What we want to know is, whether the facts, so far as they are known, afford evidence that things arose in the way described by Milton, or not; and, when that question is settled, it will be time enough to inquire as to the causes of their origination.

In the second place, I have not spoken of this doctrine as the Biblical hypothesis. It is quite true that persons as diverse in their general views as Milton the Protestant and the celebrated Jesuit Father Suarez, each read in the first chapter of Genesis the interpretation adopted by Milton. It is quite true that that interpretation, unless I mistake, is that which has been instilled into every one of us in our childhood; but I do not for one moment venture to say that it can properly be called the Biblical doctrine. In the first place, it is not my business to say what the Hebrew text contains, and what it does not; in the second place, were I to say that this is the Biblical hypothesis, I should be met by the authority of many eminent scholars, to say nothing of men of science, who in recent times have absolutely denied that this doctrine is to be found in Genesis at all. If we are to listen to them, we must believe what seems so clearly defined in Genesis—as if very great pains had been taken so that there should be no possibility of mistake—is not the meaning of the text at all. The account is divided into periods that we may make just as long as convenience requires. We are also to understand that it is consistent with that phraseology to believe that plants and animals may have been evolved by natural processes, lasting for millions of years, out

of similar rudiments. A person who is not a Hebrew scholar can only stand by and admire the marvelous flexibility of a language which admits of such diverse interpretations.

Assuredly, in the face of such contradictory authority upon matters upon which he is competent to form no judgment, he will abstain from giving any opinion, as I do. In the third place, I have carefully abstained from speaking of this as a Mosaic doctrine, because we are now assured upon the authority of the highest critics, and even of dignitaries in the Church, that there is no evidence whatever that Moses ever wrote this chapter, or knew anything about it. You will understand that I give no opinion—it would be an impertinence upon my part to volunteer an opinion upon such a subject. But, that being the state of opinion among the scholars and the clergy, it is well for us the laity, who stand outside, to avoid entangling ourselves in such a vexed question. So, as happily Milton leaves us no conceivable ambiguity as to what he means, I will continue to speak of the opinion in question as the Miltonian hypothesis.

Now we have to test that hypothesis. For my part, I have no prejudice one way or the other. If there is evidence in favor of this view, I have no sort of theoretical difficulties in the way of accepting it, but there must be evidence. We scientific men get an awkward habit—no, I won't call it that, for it is a valuable habit—of reasoning, so that we believe nothing unless there is evidence for it; and we have a way of looking upon belief which is not based upon evidence, not only as illogical, but as immoral. We will, if you please, test this view in the light of facts, for by what I have said you will understand that I don't propose to discuss the question of what testimonial evidence is to be adduced in favor of this view. If those whose business it is to judge are not at one as to the authenticity of the document, or as to the facts to which it bears witness, the discussion of testimonial evidence is superfluous. But one regards this less because the circumstantial evidence, if carefully considered, leads to the conclusion that the hypothesis is altogether inadequate, and cannot be sustained. And the considerations upon which I base that conclusion are of the simplest possible character. Whatever the flexibility of interpretation of the statement on which Milton's hypothesis is based, it is quite impossible to deny that it contains assertions of a very definite character relating to the succession of living forms. It is stated that plants, for example, made their appearance upon the third day, and not before. And you will understand that what was meant by plants are plants which now live—the trees and shrubs which we now have. One of two things—either the existing plants have been the result of a separate origination of which we have no record or ground for supposition, or else they have arisen by process of evolution from the original stock. And, in the second place, it is clear that there was no animal life before the fourth day, and that on

the fourth day marine animals and birds appeared. And it is further clear that terrestrial life made its appearance upon the sixth day, and not before. Hence, it follows that, if in the large mass of circumstantial evidence as to what really has happened in the past history of the globe—if in that we find down to a certain point indications of the existence of terrestrial animals, it is perfectly certain that all that has taken place since that time must be referred to the sixth day.

In this great Carboniferous formation whence America has derived so vast a proportion of her actual and potential wealth, in that formation and in the beds of coal which are formed from the vegetation of that period, we find abundant evidence of the existence of terrestrial animals. They have been described not only by European naturalists, but by your own naturalists. There are to be found in the coal of your own coal-fields numerous insects allied to our cockroaches. There are to be found there spiders and scorpions of large size, and so similar to existing scorpions that it requires the practised eye of the naturalist to distinguish them. Inasmuch as these things can be proved to have been alive in the Carboniferous epoch, it is perfectly clear that, if the Miltonic account is correct, the huge mass of rocks extending from the middle of the Palæozoic formations to the end of the series must belong to the day or period which is termed by Milton the sixth day of the creation. But, further, it is expressly stated that aquatic animals took their origin upon the fifth day, and did not exist before; hence all formations in which aquatic animals can be proved to exist, and which therefore lived at the time these formations were deposited, must have been deposited during the time of the period which Milton speaks of as the fifth day. But there is absolutely no fossiliferous rock in which you do not find the remains of marine animals. The lowest forms of life in the Silurian are marine animals, and, if the view which is entertained by Principal Dawson and Dr. Carpenter respecting the nature of the *Eozoön* be correct, if it is true that animal remains exist at a period as far antecedent to the deposit in the coal as the coal is from us, at the bottom of the series of stratified rocks in the Laurentian strata, it follows plainly enough that the whole series of stratified rocks, if they are to be brought into harmony with Milton at all, must be referred to the sixth day, and we cannot hope to find the slightest trace of the work of the other days in our stratified formations. When one comes to consider this, one sees how absolutely futile are the attempts that have been made to run a parallel between the story told by the stratified rocks as we know them and the account which Milton gives of it. The whole series of stratified rocks must be referred to the last two periods, and neither the Carboniferous nor any other formation can afford evidence of the work of the third day. Not only is there this objection to any attempt to run a parallel between the Miltonic account and the actual facts, but there is a further difficulty. In the

Miltonic account the order in which animals should have made their appearance in the stratified rock would be this: Fishes, including the great whales, and birds; after that, all varieties of terrestrial animals. Nothing could be further from the facts as we find them. As a matter of fact we know of not the slightest evidence of the existence of birds before the Jurassic and perhaps the Triassic formations.

If there were any parallel between the Miltonic account and the circumstantial evidence, we ought to have abundant evidence of the existence of birds in the Devonian, the Silurian, and the Carboniferous rocks. I need hardly tell you that this is not the case, and that not a trace of birds makes its appearance until the far later period which I have mentioned.

And again, if it be true that all varieties of fishes and the great whales, and the like, made their appearance on the fifth day, then we ought to find the remains of these things in the older rocks—in those which preceded the Carboniferous epoch. Fishes, it is true, we find, and numerous ones; but the great whales are absent, and the fishes are not such as now live. Not one solitary species of fish now in existence is to be found there, and hence you are introduced again to the dilemma that either the creatures which were created then, which came into existence the sixth day, were not those which are found at present, are not the direct and immediate predecessors of those which now exist; in which case you must either have had a fresh creation of which nothing is said, or a process of evolution; or else the whole story must be given up, as not only devoid of any circumstantial evidence, but contrary to that evidence.

I placed before you in a few words, some little time ago, a statement of the sum and substance of Milton's hypothesis. Let me try now to put before you as briefly the effect of the circumstantial evidence as to the past history of the earth which is written without the possibility of mistake, with no chance of error, in the stratified rocks. What we find is, that that great series of formations represents a period of time of which our human chronologies hardly afford us a unit of measure. I will not pretend to say how we ought to measure this time, in millions or in billions of years. Happily for my purpose, that is wholly unessential. But that the time was enormous, there is no sort of question.

It results from the simplest methods of interpretation, that all that is now dry land has once been at the bottom of the waters. Leaving out of view certain patches of metamorphosed rocks, certain volcanic products, it is perfectly certain that at a comparatively recent period of the world's history—the Cretaceous epoch—none of the great physical features which at present mark the surface of the globe existed. It is certain that the Rocky Mountains were not. It is certain that the Himalaya Mountains were not. It is certain that the Alps and the Pyrenees had no existence. The evidence is of the plainest pos-

sible character, and is simply this: We find raised up on the flanks of these mountains, elevated by the forces of upheaval which have given rise to them, masses of cretaceous rock which formed the bottom of the sea before those mountains existed. It is therefore perfectly clear that the elementary forces which gave rise to the mountains operated subsequently to the Cretaceous epoch; that the mountains themselves are largely made up of the materials deposited in the sea which once occupied their place. We meet as we go back in time with constant alternations of sea and land, of estuary and open ocean, and in correspondence with these alternations we meet with changes in the fauna and flora of the kind I have stated.

But no inspection of these changes gives us the slightest right to believe that there has been any discontinuity in natural processes. There is no trace of cataclysm, of great sweeping deluges or universal destructions of organic life. The appearances which were formerly interpreted that way have all been shown to be delusive as our knowledge has increased and as the blanks between the different formations have been filled up. It can now be shown that there is no absolute break between formation and formation, that there has been no sudden disappearance of all the forms of life at one time and replacement by another, but that everything has gone on slowly and gradually, that one form has died out and another has taken its place, and that thus by slow degrees one fauna has been replaced by another. So that, within the whole of the immense period indicated by these stratified rocks, there is assuredly—leaving evolution out of the question altogether—not the slightest trace of any break in the uniformity of Nature's operations, not a shadow of indication that events have followed other than their natural and orderly sequence.

That, I say, is the most natural teaching of the circumstantial evidence contained in the stratified rock. I leave you to consider how far by any ingenuity of interpretation, by any stretching of the meaning of language, it can be brought into the smallest similarity with that view which I have put before you as the Miltonic doctrine.

There remains the third hypothesis—what I have spoken of as the hypothesis of evolution; and I propose that in lectures to come we should consider that as carefully as we have considered the other two hypotheses. I need not say that it is quite hopeless to look for testimonial evidence of evolution. The very nature of the case precludes the possibility of such evidence. Our sole inquiry is, what foundation circumstantial evidence lends to that hypothesis, or whether it lends any, or whether it controverts it; and I should deal with the matter entirely as a question of history. I shall not indulge in the discussion of any speculative probabilities. I shall not attempt to show that Nature is unintelligible unless we adopt some such hypothesis: for anything I know about it, it may be the way of Nature to be unintelligible. She is often puzzling, and I have no reason to suppose she

is bound to fit herself to our notions; but I shall deal with the matter entirely from the point of view of history, and I shall place before you three kinds of evidence entirely based upon what we know of the forms of animal life which are contained in the series of stratified rock. I shall endeavor to show you that there is one kind of evidence which is neutral, which neither helps evolution nor is inconsistent with it. I shall then endeavor to show you that there is a second kind of evidence which indicates a strong probability in favor of evolution, but does not prove it; and, lastly, I shall endeavor to show that there is a third kind of evidence which, being as complete as any evidence which we can hope to obtain upon such a subject, and being wholly and entirely in favor of evolution, may be fairly called demonstrative evidence of its having occurred.

THE MOON'S INFLUENCE ON THE WEATHER.[1]

By Professor M. A. F. PRESTEL.

A SUDDEN and considerable fall of the barometer is of frequent occurrence; but to find a case identical with that of November 22, 1873, I had to search my journals for many years back. It is worthy of note that, in 1854, an equally sudden and considerable fall of the barometer took place here on the coast of the North Sea on precisely the same days as in 1873. According to observations made at Emden, the barometric column on November 21, 1873, at 6 A. M., was 762.3 millimetres, and it then fell steadily till 2 P. M. on the 22d, when it reached the minimum, 732.5 millimetres, and then it again began to rise. At 6 A. M. of November 21, 1854, the barometer stood 760.7 millimetres, and the mercurial column then steadily fell until 6 A. M., November 23d, when it was 734.7 millimetres; it then began to rise. The point to which I would call special attention is that, on the occasion of both of these great falls of the barometer, the position of the moon with respect to the earth was precisely the same. There was new moon at 3 A. M. of November 20, 1873, and at 8 A. M. of November 20, 1854; in 1873 the moon entered the southern lunistice at 3 A. M. on November 23d, and in 1854 at 6 A. M. of November 23d; in both years the moon's declination on November 23d was 27° south.

Still, the occurrence of storms and barometric minima over Northwestern Europe on November 22, 1873 and 1854, at the period of the lunistitia and of the new moon, might be merely accidental; but that it was not accidental is shown by sundry mutually corresponding phenomena in the atmosphere, which were observed during these two

[1] Translated from the German by J. Fitzgerald, A. M.

years. During the month of October, 1873, the average height of the barometric column was 757.1 millimetres, and for the same month in 1854 it was 757.2 millimetres; the barometric mean for the five days between the 22d and the 28th was, in 1873, 750.7 millimetres, and in 1854, 748.7 millimetres; the minimum was reached, in 1873, on October 23d, and in 1854 on October 25th, being in the former case 734.9 millimetres, and in the latter 734.5 millimetres. In 1873 the maximum was reached in the evening of October 28th—773.7 millimetres, and in 1854 at noon of the 28th—774.9 millimetres. The weather was also the same in both years from the 3d to the 7th, and from the 21st to the 27th of October. From the 5th to the 7th there were frequent and heavy falls of rain; on the 7th, in 1873, and on the 5th, in 1854, there were violent thunder-storms. On both years from the 21st to the 25th the atmosphere was in a state of violent disturbance, the barometric column being very low. And here we may state that there was new moon at 11 A. M. on October 21, 1873, and at 9 P. M. on October 21, 1854; that in 1873 the southern lunistice occurred at 10 P. M. of the 26th, and in 1854 at 9 P. M. of the 26th; and that the moon's declination at the time was about 27° south.

Further, from the 13th to the 16th of November, 1873, the distribution of atmospheric pressure over Europe and the state of the weather were similar to what they were on the same days in 1854. The fearful ravages wrought by the storms in the Black Sea on the days between the 13th and the 16th of November, 1854 (the Crimean War being then in progress), will render those days ever memorable. The numerous shipwrecks in the sea of Azof, and the loss of English and French war-ships in the Black Sea on the 13th and 14th, showed how desirable and necessary a thing it was that there should be found some means of warning seafarers of the approach of storms. It was these disasters which gave occasion to the establishment of storm-signals. From the 13th to the 15th of November, 1873, after a period of calm, with high barometer over the greater part of Northwestern Europe, we find succeeding a similar barometric minimum, and a storm area advancing across the Mediterranean toward the Black Sea.

At any given point of the earth's surface the state of the weather always depends on the prevailing air-currents. The annual and the secular periodic changes of the oceanic and the atmospheric currents are repeated in the weather-changes. And on the phenomena which, however imperfectly, establish this periodicity, is based the universal belief that the moon has an influence on the weather. The researches and calculations which have been made by meteorologists to determine the periodicity of weather phenomena, and the influence of the moon upon the latter, have hitherto been fruitless, and this simply because the observations of single stations only have been taken into account. From observations made at one point it is impossible to

obtain decisive results as to secular periodic weather-changes, even though these observations were to be carried on for a hundred years or more. The terrestrial atmospheric currents, in their passage over the same portion of the earth's surface (whether this passage be periodic or not periodic), never take the same route, or have the same limits, and consequently the localities over which they pass on their return will happen to be at one time in the centre of the current, at another time more or less near to its northern or its southern edge.

Under these circumstances the state of barometer and of thermometer, the amount of precipitation, the force of the wind, etc., upon which these researches are based, must yield conflicting results. Some, however, have supposed that better results might be obtained by combining these quantities, and taking the mean of all the readings. This method quite does away with anomalies, it is true, but then the result has no specific value whatever, though the aim of all such researches must always be to determine the weather specifically. The periodicity of weather phenomena can only be determined by means of investigations carried on according to the geographical method, i. e., by studying these atmospheric phenomena in their continuity both as regards time and space.

As has been already said, the track of the storm of November 17th–23d lay over nearly the same regions of the northern hemisphere in 1873 and 1854. Had these air-currents taken a course only a few degrees more to the north or to the south, their existence and their identity would have been so ill determined by the barometer of a single locality that they might easily have been overlooked.

On the 28th of November, 1873, at 10 P. M., the barometer at Emden stood at 756.4 millimetres, and then kept on falling till the 30th, at 8 A. M., when it was 744.2 millimetres; after this it rose till at 10 P. M. it was 762.6 millimetres. This not very considerable fall of the barometer would not have deserved special notice, were it not followed on the evening of the 29th by a storm of some violence, which through the night became a hurricane. In 1854, at the same period of the year, the barometer underwent a similar change, only much greater. On November 27th, at 10 P. M., the height of the barometric column was 757 millimetres. It then fell, till on the 29th, at 2 P. M., it was 727.8 millimetres, when it began rising till it reached 757.9 millimetres at 8 A. M., on the 30th. The quantitative difference of barometric pressure at Emden on November 27th and 28th, between the years 1873 and 1854, is simply the result of the difference in the tracks of the storms, and the consequent distance of the place of observation from the storm-centre. At Thorshavn, between November 25th and 28th, in 1873, the barometric changes were precisely the same as had been observed at Emden on the same days in 1854. In 1873, at 9 P. M. of the 25th, the mercurial column at Thorshavn was 757.3 millimetres; on the 26th, at 8 A. M., it was 746.9 millimetres; on the 26th at 9 P. M.,

729.2 millimetres; on the 27th, at 8 A. M., 729.8 millimetres; on the 28th, at 8 A. M., 747.3 millimetres.

With the moon in a like position with respect to the earth, there occurred, December 15–18, 1873 and 1854, just as on the 21st and 22d of November, a sudden and great fall of the barometer, accompanied by a fearful storm. In 1873, on the evening of the 13th, and in 1854, on the morning of the 14th, the moon was in the descending node. The moon's declination in 1873, at 3 P. M. of the 15th, and in 1854 at 7 A. M. of the 16th, was 12° south. At Emden, in 1873, the barometer fell on the 15th and 16th, from 768 to 745 millimetres, or 23 millimetres. At Skudesnäs the fall on the 15th and 16th December amounted to 25 millimetres; at Stockholm, on the 16th, to 20 millimetres; at St. Petersburg, from the 15th to the 17th, to 30 millimetres. The track of the centre of this storm entirely agrees with that of the storm of November 14th–22d. At 1 A. M. of December 14th, we find at Washington, North Carolina, a barometric minimum of 744.2 millimetres, and by $7^{h.}$ $35^{m.}$ this had advanced as far as Halifax. Here, at the time specified, the barometer had fallen to 735 millimetres. On the 14th, at $4^{h.}$ $35^{m.}$, the barometric minimum had passed in a northeast direction over Newfoundland, crossing the Atlantic Ocean. At Thorshavn, where, on the 14th, at 8 A. M., the barometer had stood at 757.4 millimetres, it had on the morning of the 16th fallen to 731.9. At Aberdeen, the barometer on the morning of the 16th stood at 735 millimetres.

In 1854, on the morning of December 17th, the barometer at Emden showed 752.2 millimetres; it then fell till noon on the 18th, when it was 731.1 millimetres, and then began to rise again. At the beginning of the fall of the barometer, a storm from the southwest set in, which increased in force till it became a hurricane. The rain which fell during the storm amounted to 18.9 millimetres.

At Cologne, at $3^{h.}$ $41^{m.}$, December 18, 1854, the barometer showed 726.6 millimetres—a barometric minimum never before observed there since 1830.

In 1854 the track of the storm-centre traversed Northern France and Germany: thus, as on November 22d, it was more southerly than in 1873.

Such concordant atmospheric phenomena as these, when the moon occupies the same position relating to the earth, might be quoted at great length. *The moon, as it governs ebb and flow, so too determines oceanic currents, and, by means of these, atmospheric currents.* From this it follows that the influence of the moon upon that portion of the atmosphere which overlies the continents must be less than that upon the supra-oceanic atmosphere.—*Gaea.*

DIFFICULTIES OF DEVELOPMENT AS APPLIED TO MAN.[1]

By ALFRED RUSSEL WALLACE, F. R. S.

AS my own knowledge of and interest in anthropology are confined to the great outlines, rather than to the special details of the science, I propose to give a very brief and general sketch of the modern doctrine as to the Antiquity and Origin of Man, and to suggest certain points of difficulty which have not, I think, yet received sufficient attention.

Many now present remember the time (for it is little more than twenty years ago) when the antiquity of man, as now understood, was universally discredited. Not only theologians, but even geologists, then taught us that man belonged altogether to the existing state of things; that the extinct animals of the Tertiary period had finally disappeared, and that the earth's surface had assumed its present condition, before the human race first came into existence. So prepossessed were even scientific men with this idea—which yet rested on purely negative evidence, and could not be supported by any arguments of scientific value—that numerous facts which had been presented at intervals for half a century, all tending to prove the existence of man at very remote epochs, were silently ignored; and, more than this, the detailed statements of three distinct and careful observers were rejected by a great scientific society as too improbable for publication, only because they proved (if they were true) the coexistence of man with extinct animals![2]

But this state of belief in opposition to facts could not long continue. In 1859 a few of our most eminent geologists examined for themselves into the alleged occurrence of flint implements in the gravels of the north of France, which had been made public fourteen years before, and found them strictly correct. The caverns of Devonshire were about the same time carefully examined by equally eminent observers, and were found fully to bear out the statements of those who had published their results eighteen years before. Flint implements began to be found in all suitable localities in the south of England, when carefully searched for, often in gravels of equal antiquity with those of France. Caverns, giving evidence of human occupation

[1] From the opening address of Mr. Wallace, as President of the Biological Section of the British Association for the Advancement of Science, given at its recent meeting in Glasgow.

[2] In 1854 (?) a communication from the Torquay Natural History Society, confirming previous accounts by Mr. Godwin-Austen, Mr. Vivian, and the Rev. Mr. McEnery, that worked flints occurred in Kent's Hole, with remains of extinct species, was rejected as too improbable for publication.

at various remote periods, were explored in Belgium and the south of France—lake-dwellings were examined in Switzerland—refuse-heaps in Denmark—and thus a whole series of remains have been discovered, carrying back the history of mankind from the earliest historic periods to a long-distant past. The antiquity of the races thus discovered can only be generally determined by the successively earlier and earlier stages through which we can trace them. As we go back, metals soon disappear, and we find only tools and weapons of stone and of bone. The stone weapons get ruder and ruder; pottery, and then the bone implements, cease to occur; and in the earliest stage we find only chipped flints, of rude design, though still of unmistakably human workmanship. In like manner domestic animals disappear as we go backward; and, though the dog seems to have been the earliest, it is doubtful whether the makers of the ruder flint implements of the gravels possessed even this. Still more important as a measure of time are the changes of the earth's surface—of the distribution of animals—and of climate—which have occurred during the human period. At a comparatively recent epoch in the record of prehistoric times, we find that the Baltic was far salter than it is now, and produced abundance of oysters; and that Denmark was covered with pine-forests inhabited by capercailzies, such as now only occur farther north in Norway. A little earlier we find that reindeer were common even in the south of France, and still earlier this animal was accompanied by the mammoth and woolly rhinoceros, by the arctic glutton, and by huge bears and lions of extinct species. The presence of such animals implies a change of climate, and both in the caves and gravels we find proofs of a much colder climate than now prevails in Western Europe. Still more remarkable are the changes of the earth's surface which have been effected during man's occupation of it. Many extensive valleys in England and France are believed by the best observers to have been deepened at least a hundred feet; caverns now far out of the reach of any stream must for a long succession of years have had streams flowing through them, at least in times of floods—and this often implies that vast masses of solid rock have since been worn away. In Sardinia land has risen at least three hundred feet since men lived there who made pottery and probably used fishing-nets;[1] while in Kent's Cavern remains of man are found buried beneath two separate beds of stalagmite, each having a distinct texture, and each covering a deposit of cave-earth having well-marked differential characters, while each contains a distinct assemblage of extinct animals.

Such, briefly, are the results of the evidence that has been rapidly accumulating for about fifteen years as to the antiquity of man; and it has been confirmed by so many discoveries of a like nature in all parts of the globe, and especially by the comparison of the tools and

[1] Lyell's "Antiquity of Man," fourth edition, p. 115.

weapons of prehistoric man with those of modern savages, so that the use of even the rudest flint implements has become quite intelligible, that we can hardly wonder at the vast revolution effected in public opinion. Not only is the belief in man's vast and still unknown antiquity universal among men of science, but it is hardly disputed by any well-informed theologian; and the present generation of science-students must, we should think, be somewhat puzzled to understand what there was in the earliest discoveries that should have aroused such general opposition and been met with such universal incredulity.

But the question of the mere "Antiquity of Man" almost sank into insignificance at a very early period of the inquiry, in comparison with the far more momentous and more exciting problem of the development of man from some lower animal form, which the theories of Mr. Darwin and of Mr. Herbert Spencer soon showed to be inseparably bound up with it. This has been, and to some extent still is, the subject of fierce conflict; but the controversy as to the fact of such development is now almost at an end, since one of the most talented representatives of Catholic theology, and an anatomist of high standing—Prof. Mivart—fully adopts it as regards physical structure, reserving his opposition for those parts of the theory which would deduce man's whole intellectual and moral nature from the same source, and by a similar mode of development.

Never, perhaps, in the whole history of science or philosophy has so great a revolution in thought and opinion been effected as in the twelve years from 1859 to 1871, the respective dates of publication of Mr. Darwin's "Origin of Species" and "Descent of Man." Up to the commencement of this period the belief in the independent creation or origin of the species of animals and plants, and the belief in the very recent appearance of man upon the earth, were, practically, universal. Long before the end of it these two beliefs had utterly disappeared, not only in the scientific world, but almost equally so among the literary and educated classes generally. The belief in the independent origin of man held its ground somewhat longer, but the publication of Mr. Darwin's great work gave even that its death-blow, for hardly any one capable of judging of the evidence now doubts the derivative nature of man's bodily structure as a whole, although many believe that his mind and even some of his physical characteristics may be due to the action of other forces than have acted in the case of the lower animals.

We need hardly be surprised, under these circumstances, if there has been a tendency among men of science to pass from one extreme to the other, from a profession (so few years ago) of total ignorance as to the mode of origin of all living things, to a claim to almost complete knowledge of the whole progress of the universe from the first speck of living protoplasm up to the highest development of the human intellect. Yet this is really what we have seen in the last six-

teen years. Formerly difficulties were exaggerated, and it was asserted that we had not sufficient knowledge to venture on any generalizations on the subject. Now difficulties are set aside, and it is held that our theories are so well established and so far-reaching, that they explain and comprehend all Nature. It is not long ago (as I have already reminded you) since *facts* were contemptuously ignored, because they favored our now popular views; at the present day it seems to me that facts which oppose them hardly receive due consideration. And, as opposition is the best incentive to progress, and it is not well even for the best theories to have it all their own way, I propose to direct your attention to a few such facts, and to the conclusions that seem fairly deducible from them.

It is a curious circumstance that, notwithstanding the attention that has been directed to the subject in every part of the world, and the numerous excavations connected with railways and mines which have offered such facilities for geological discovery, no advance whatever has been made for a considerable number of years, in detecting the time or the mode of man's origin. The Palæolithic flint weapons first discovered in the north of France more than thirty years ago are still the oldest undisputed proofs of man's existence; and, amid the countless relics of a former world that have been brought to light, no evidence of any one of the links that must have connected man with the lower animals has yet appeared.

It is, indeed, well known that negative evidence in geology is of very slender value, and this is, no doubt, generally the case. The circumstances here are, however, peculiar; for many converging lines of evidence show that, on the theory of development by the same laws which have determined the development of the lower animals, man must be immensely older than any traces of him yet discovered. As this is a point of great interest, we must devote a few moments to its consideration:

1. The most important difference between man and such of the lower animals as most nearly approach him is undoubtedly in the bulk and development of his brain, as indicated by the form and capacity of the cranium. We should therefore anticipate that these earliest races, who were contemporary with the extinct animals and used rude stone weapons, would show a marked deficiency in this respect. Yet the oldest known crania—those of the Engis and Cro-Magnon caves—show no marks of degradation. The former does not present so low a type as that of most existing savages, but is—to use the words of Prof. Huxley—"a fair average human skull, which might have belonged to a philosopher, or might have contained the thoughtless brains of a savage." The latter are still more remarkable, being unusually large and well formed. Dr. Pruner-Bey states that they surpass the average of modern European skulls in capacity, while their symmetrical forms, without any trace of prognathism, compare

favorably not only with the foremost savage races, but with many civilized nations of modern times.

One or two other crania of much lower type, but of less antiquity than this, have been discovered; but they in no way invalidate the conclusion which so highly developed a form at so early a period implies, viz., that we have as yet made a hardly perceptible step toward the discovery of any earlier stage in the development of man.

2. This conclusion is supported and enforced by the nature of many of the works of art found even in the oldest cave-dwellings. The flints are of the old chipped type, but they are formed into a large variety of tools and weapons—such as scrapers, awls, hammers, saws, lances, etc.—implying a variety of purposes for which these were used, and a corresponding degree of mental activity and civilization. Numerous articles of bone have also been found, including well-formed needles, implying that skins were sewn together, and perhaps even textile materials woven into cloth. Still more important are the numerous carvings and drawings representing a variety of animals, including horses, reindeer, and even a mammoth, executed with considerable skill on bone, reindeer horns, and mammoth-tusks. These, taken together, indicate a state of civilization much higher than that of the lowest of our modern savages, while it is quite compatible with a considerable degree of mental advancement, and leads us to believe that the crania of Engis and Cro-Magnon are not exceptional, but fairly represent the characters of the race. If we further remember that these people lived in Europe under the unfavorable conditions of a sub-arctic climate, we shall be inclined to agree with Dr. Daniel Wilson, that it is far easier to produce evidences of deterioration than of progress in instituting a comparison between the contemporaries of the mammoth and later prehistoric races of Europe or savage nations of modern times.[1]

3. Yet another important line of evidence as to the extreme antiquity of the human type has been brought prominently forward by Prof. Mivart.[2] He shows, by careful comparison of all parts of the structure of the body, that man is related, not to any one, but almost equally to many of the existing apes—to the orang, the chimpanzee, the gorilla, and even to the gibbons—in a variety of ways; and these relations and differences are so numerous and so diverse that on the theory of evolution the ancestral form which ultimately developed into man must have diverged from the common stock whence all these various forms and their extinct allies originated. But so far back as the Miocene deposits of Europe, we find the remains of apes allied to these various forms, and especially to the gibbons, so that in all probability the special line of variation which led up to man branched off at a still earlier period. And these early forms, being the initiation of a far higher type, and having to develop by

[1] "Prehistoric Man," third edition, vol. i., p. 117. [2] "Man and Apes," pp. 171–193.

natural selection into so specialized and altogether distinct a creature as man, must have risen at a very early period into the position of a dominant race, and spread in dense waves of population over all suitable portions of the great continent—for this, on Mr. Darwin's hypothesis, is essential to rapid developmental progress through the agency of natural selection.

Under these circumstances we might certainly expect to find some relics of these earlier forms of man along with those of animals which were presumably less abundant. Negative evidence of this kind is not very weighty, but still it has *some* value. It has been suggested that as apes are mostly tropical, and anthropoid apes are now confined almost exclusively to the vicinity of the equator, we should expect the ancestral forms also to have inhabited these same localities—West Africa and the Malay Islands. But this objection is hardly valid, because existing anthropoid apes are wholly dependent on a perennial supply of easily-accessible fruits, which is only found near the equator, while not only had the south of Europe an almost tropical climate in Miocene times, but we must suppose even the earliest ancestors of man to have been terrestrial and omnivorous, since it must have taken ages of slow modification to have produced the perfectly erect form, the short arms, and the wholly non-prehensile foot, which so strongly differentiate man from the apes.

The conclusion which I think we must arrive at is, that if man has been developed from a common ancestor with all existing apes, *and by no other agencies than such as have affected their development*, then he must have existed in something approaching his present form, during the Tertiary period—and not merely existed, but predominated in numbers, wherever suitable conditions prevailed. If, then, continued researches in all parts of Europe and Asia fail to bring to light any proofs of his presence, it will be at least a presumption that he came into existence at a much later date, and by a much more rapid process of development. In that case it will be a fair argument that, just as he is in his mental and moral nature, his capacities and aspirations, so infinitely raised above the brutes, so his origin is due to distinct and higher agencies than such as have affected their development.

There is yet another line of inquiry bearing upon this subject to which I wish to call your attention. It is a somewhat curious fact that, while all modern writers admit the great antiquity of man, most of them maintain the very recent development of his intellect, and will hardly contemplate the possibility of men, equal in mental capacity to ourselves, having existed in prehistoric times. This question is generally assumed to be settled by such relics as have been preserved of the manufactures of the older races, showing a lower and lower state of the arts by the successive disappearance in early times of iron, bronze, and pottery; and by the ruder forms of the older flint

implements. The weakness of this argument has been well shown by Mr. Albert Mott in his very original but little known presidential address to the Literary and Philosophical Society of Liverpool in 1873. He maintains that "our most distant glimpses of the past are still of a world peopled as now with men both civilized and savage;" and "that we have often entirely misread the past by supposing that the outward signs of civilization must always be the same, and must be such as are found among ourselves." In support of this view he adduces a variety of striking facts and ingenious arguments, a few of which I will briefly summarize.

On one of the most remote islands of the Pacific—Easter Island—2,000 miles from South America, 2,000 from the Marquesas, and more than 1,000 from the Gambier Islands, are found hundreds of gigantic stone images, now mostly in ruins, often thirty or forty feet high, while some seem to have been much larger, the crowns on their heads cut out of a red stone, being sometimes ten feet in diameter, while even the head and neck of one are said to have been twenty feet high.[1] These once stood erect on extensive stone platforms, yet the island has only an area of about thirty square miles, or considerably less than Jersey. Now, as one of the smallest images eight feet high weighs four tons, the largest must weigh over a hundred tons if not much more; and the existence of such vast works implies a large population, abundance of food, and an established government. Yet how could these coexist in a mere speck of land wholly cut off from the rest of the world? Mr. Mott maintains that this necessarily implies the power of regular communication with larger islands or a continent, the arts of navigation, and a civilization much higher than now exists in any part of the Pacific. Very similar remains in other islands scattered widely over the Pacific add weight to this argument.

The next example is that of the ancient mounds and earthworks of the North American Continent, the bearing of which is even more significant. Over the greater part of the extensive Mississippi Valley four well-marked classes of these earthworks occur. Some are camps, or works of defense, situated on bluffs, promontories, or isolated hills; others are vast inclosures in the plains and lowlands, often of geometric forms, and having attached to them roadways or avenues often miles in length; a third are mounds corresponding to our tumuli, often seventy to ninety feet high, and some of them covering acres of ground; while a fourth group consist of representations of various animals modeled in relief on a gigantic scale, and occurring chiefly in an area somewhat to the northwest of the other classes, in the plains of Wisconsin.

The first class—the camps or fortified inclosures—resemble in general features the ancient camps of our own islands, but far surpass them in extent. Fort Hill, in Ohio, is surrounded by a wall and ditch

[1] Journal of the Royal Geographical Society, 1870, pp. 177, 178.

a mile and a half in length, part of the way cut through solid rock. Artificial reservoirs for water were made within it, while at one extremity, on a more elevated point, a keep is constructed with its separate defenses and water-reservoirs. Another, called Clark's Work, in the Scioto Valley, which seems to have been a fortified town, incloses an area of one hundred and twenty-seven acres, the embankments measuring three miles in length, and containing not less than three million cubic feet of earth. This area incloses numerous sacrificial mounds and symmetrical earthworks in which many interesting relics and works of art have been found.

The second class—the sacred inclosures—may be compared for extent and arrangement with Avebury or Carnak—but are in some respects even more remarkable. One of these, at Newark, Ohio, covers an area of several miles with its connected groups of circles, octagons, squares, ellipses, and avenues, on a grand scale, and formed by embankments from twenty to thirty feet in height. Other similar works occur in different parts of Ohio, and by accurate survey it is found not only that the circles are true, though some of them are one-third of a mile in diameter, but that other figures are truly square, each side being over one thousand feet long, and, what is still more important, the dimensions of some of these geometrical figures in different parts of the country, and seventy miles apart, are identical. Now, this proves the use, by the builders of these works, of some standard measures of length, while the accuracy of the squares, circles, and, in a less degree, of the octagonal figures, shows a considerable knowledge of rudimentary geometry, and some means of measuring angles. The difficulty of drawing such figures on a large scale is much greater than any one would imagine who has not tried it, and the accuracy of these is far beyond what is necessary to satisfy the eye. We must therefore impute to these people the wish to make these figures as accurate as possible, and this wish is a greater proof of habitual skill and intellectual advancement than even the ability to draw such figures. If, then, we take into account this ability and this love of geometric truth, and further consider the dense population and civil organization implied by the construction of such extensive systematic works, we must allow that these people had reached the earlier stages of a civilization of which no traces existed among the savage tribes who alone occupied the country when first visited by Europeans.

The animal mounds are of comparatively less importance for our present purpose, as they imply a somewhat lower grade of advancement; but the sepulchral and sacrificial mounds exist in vast numbers, and their partial exploration has yielded a quantity of articles and works of art which throw some further light on the peculiarities of this mysterious people. Most of these mounds contain a large concave hearth or basin of burnt clay, of perfectly symmetrical

form, on which are found deposited more or less abundant relics, all bearing traces of the action of fire. We are, therefore, only acquainted with such articles as are practically fire-proof. These consist of bone and copper implements and ornaments, disks, and tubes—pearl, shell, and silver beads, more or less injured by the fire—ornaments cut in mica, ornamental pottery, and numbers of elaborate carvings in stone, mostly forming pipes for smoking. The metallic articles are all formed by hammering, but the execution is very good; plates of mica are found cut into scrolls and circles; the pottery, of which very few remains have been found, is far superior to that of any of the Indian tribes, since Dr. Wilson is of opinion that they must have been formed on a wheel, as they are often of uniform thickness throughout (sometimes not more than one-sixth of an inch), polished and ornamented with scrolls and figures of birds and flowers in delicate relief. But the most instructive objects are the sculptured stone pipes, representing not only various easily-recognizable animals, but also human heads, so well executed that they appear to be portraits. Among the animals, not only are such native forms as the panther, bear, otter, wolf, beaver, raccoon, heron, crow, turtle, frog, rattlesnake, and many others, well represented, but also the manatee, which perhaps then ascended the Mississippi as it now does the Amazon, and the toucan, which could hardly have been obtained nearer than Mexico. The sculptured heads are especially remarkable, because they present to us the features of an intellectual and civilized people. The nose in some is perfectly straight, and neither prominent nor dilated, the mouth is small, and the lips thin, the chin and upper lip are short, contrasting with the ponderous jaw of the modern Indian, while the cheek-bones present no marked prominence. Other examples have the nose somewhat projecting at the apex in a manner quite unlike the features of any American indigenes, and, although there are some which show a much coarser face, it is very difficult to see in any of them that close resemblance to the Indian type which these sculptures have been said to exhibit. The few authentic crania from the mounds present corresponding features, being far more symmetrical and better developed in the frontal region than those of any American tribes, although somewhat resembling them in the occipital outline;[1] while one was described by its discoverer (Mr. W. Marshall Anderson) as "a beautiful skull worthy of a Greek."

The antiquity of this remarkable race may perhaps not be very great, as compared with the prehistoric man of Europe, although the opinions of some writers on the subject seem affected by that "parsimony of time" on which the late Sir Charles Lyell so often dilated. The mounds are all overgrown with dense forest, and one of the large trees was estimated to be 800 years old, while other observers consider the forest-growth to indicate an age of at least 1,000 years. But

[1] Wilson's "Prehistoric Man," third edition, vol. ii., pp. 123–130.

it is well known that it requires several generations of trees to pass away before the growth on a deserted clearing comes to correspond with that of the surrounding virgin forest, while this forest, once established, may go on growing for an unknown number of thousands of years. The 800 or 1,000 years estimate from the growth of existing vegetation is a minimum which has no bearing whatever on the actual age of these mounds, and we might almost as well attempt to determine the time of the glacial epoch from the age of the pines or oaks which now grow on the moraines.

The important thing for us, however, is, that when North America was first settled by Europeans, the Indian tribes inhabiting it had no knowledge or tradition of any preceding race of higher civilization than themselves. Yet we find that such a race existed; that they must have been populous, and have lived under some established government; while there are signs that they practised agriculture largely, as indeed they must have done to have supported a population capable of executing such gigantic works in such vast profusion—for it is stated that the mounds and earthworks of various kinds in the State of Ohio alone amount to between eleven and twelve thousand. In their habits, customs, religion, and arts, they differed strikingly from all the Indian tribes; while their love of art and geometric forms and their capacity for executing the latter upon so gigantic a scale render it probable that they were a really civilized people, although the form their civilization took may have been very different from that of later people subject to very different influences, and the inheritors of a longer series of ancestral civilizations. We have here, at all events, a striking example of the transition, over an extensive country, from comparative civilization to comparative barbarism, the former having left no tradition, and hardly any trace of influence on the latter.

As Mr. Mott well remarks: "Nothing can be more striking than the fact that Easter Island and North America both give the same testimony as to the origin of the savage life found in them, although in all circumstances and surroundings the two cases are so different. If no stone monuments had been constructed in Easter Island, or mounds, containing a few relics saved from fire, in the United States, we might never have suspected the existence of these ancient peoples." He argues, therefore, that it is very easy for the records of an ancient nation's life entirely to perish, or to be hidden from observation. Even the arts of Nineveh and Babylon were unknown only a generation ago, and we have only just discovered the facts about the mound-builders of North America.

But other parts of the American Continent exhibit parallel phenomena. Recent investigations show that in Mexico, Central America, and Peru, the existing race of Indians has been preceded by a distinct and more civilized race. This is proved by the sculptures of the ruined cities of Central America, by the more ancient *terra-Cottas*

and paintings of Mexico, and by the oldest portrait-pottery of Peru. All alike show markedly non-Indian features, while they often closely resemble modern European types. Ancient crania, too, have been found in all these countries, presenting very different characters from those of any of the modern indigenous races of America.[1]

There is one other striking example of a higher being succeeded by a lower degree of knowledge, which is in danger of being forgotten because it has been made the foundation of theories which seem wild and fantastic, and are probably in great part erroneous. I allude to the Great Pyramid of Egypt, whose form, dimensions, structure, and uses, have recently been the subject of elaborate works by Prof. Piazzi Smyth. Now, the admitted facts about this pyramid are so interesting and so apposite to the subject we are considering, that I beg to recall them to your attention. Most of you are aware that this pyramid has been carefully explored and measured by successive Egyptologists, and that the dimensions have lately become capable of more accurate determination, owing to the discovery of some of the original casing-stones and the clearing away of the earth from the corners of the foundation, showing the sockets in which the corner-stones fitted. Prof. Smyth devoted many months of work with the best instruments in order to fix the dimensions and angles of all accessible parts of the structure; and he has carefully determined these by a comparison of his own and all previous measures, the best of which agree pretty closely with each other. The results arrived at are:

1. That the pyramid is truly square, the sides being equal and the angles right angles.

2. That the four sockets on which the first four stones of the corners rested are truly on the same level.

3. That the directions of the sides are accurately to the four cardinal points.

4. That the vertical height of the pyramid bears the same proportion to its circumference at the base as the radius of a circle does to its circumference.

Now all these measures, angles, and levels, are accurate, not as an ordinary surveyor or builder could make them, but to such a degree as requires the very best modern instruments and all the refinements of geodetical science to discover any error at all. In addition to this we have the wonderful perfection of the workmanship in the interior of the pyramid, the passages and chambers being lined with huge blocks of stones fitted with the utmost accuracy, while every part of the building exhibits the highest structural science.

In all these respects this largest pyramid surpasses every other in Egypt. Yet it is universally admitted to be the oldest, and also the oldest historical building in the world.

[1] Wilson's "Prehistoric Man," third edition, vol. ii., pp. 125, 144.

Now these admitted facts about the Great Pyramid are surely remarkable, and worthy of the deepest consideration. They are facts which, in the pregnant words of the late Sir John Herschel, "according to received theories ought not to happen," and which, he tells us, should therefore be kept ever present to our minds, since "they belong to the class of facts which serve as the clew to new discoveries." According to modern theories, the higher civilization is ever a growth and an outcome from a preceding lower state; and it is inferred that this progress is visible to us throughout all history and in all the material records of human intellect. But here we have a building which marks the very dawn of history—which is the oldest authentic monument of man's genius and skill, and which, instead of being far inferior, is very much superior to all which followed it. Great men are the products of their age and country, and the designer and constructors of this wonderful monument could never have arisen among an unintellectual and half-barbarous people. So perfect a work implies many preceding less perfect works which have disappeared. It marks the culminating point of an ancient civilization, of the early stages of which we have no record whatever.

The three cases to which I have now adverted (and there are many others) seem to require for their satisfactory interpretation a somewhat different view of human progress from that which is now generally accepted. Taken in connection with the great intellectual power of the ancient Greeks—which Mr. Galton believes to have been far above that of the average of any modern nation—and the elevation, at once intellectual and moral, displayed in the writings of Confucius, Zoroaster, and the Vedas, they point to the conclusion that, while in material progress there has been a tolerably steady advance, man's intellectual and moral development reached almost its highest level in a very remote past. The lower, the more animal, but often the more energetic types, have, however, always been far the more numerous; hence such established societies as have here and there arisen under the guidance of higher minds have always been liable to be swept away by the incursions of barbarians. Thus, in almost every part of the globe there may have been a long succession of partial civilization, each in turn succeeded by a period of barbarism; and this view seems supported by the occurrence of degraded types of skull along with such "as might have belonged to a philosopher"—at a time when the mammoth and the reindeer inhabited Southern France.

Nor need we fear that there is not time enough for the rise and decay of so many successive civilizations as this view would imply; for the opinion is now gaining ground among geologists that palæolithic man was really preglacial, and that the great gap—marked alike by a change of physical conditions, and of animal life—which in Europe always separates him from his neolithic successor, was caused by the coming on and passing away of the great Ice age.

If the views now advanced are correct, many, perhaps most, of our existing savages are the successors of higher races; and their arts, often showing a wonderful similarity in distant continents, may have been derived from a common source among more civilized peoples.

I must now conclude this very imperfect sketch of a few of the offshoots from the great tree of biological study. It will, perhaps, be thought by some that my remarks have tended to the depreciation of our science, by hinting at imperfections in our knowledge and errors in our theories, where more enthusiastic students see nothing but established truths. But I trust that I may have conveyed to many of my hearers a different impression. I have endeavored to show that even in what are usually considered the more trivial and superficial characters presented by natural objects, a whole field of new inquiry is opened up to us by the study of distribution and local conditions. And as regards man, I have endeavored to fix your attention on a class of facts which indicate that the course of his development has been far less direct and simple than has hitherto been supposed; and that, instead of resembling a single tide with its advancing and receding ripples, it must rather be compared to the progress from neap to spring tides, both the rise and the depression being comparatively greater as the waters of true civilization slowly advance toward the highest level they can reach.

And if we are thus led to believe that our present knowledge of Nature is somewhat less complete than we have been accustomed to consider it, this is only what we might expect; for, however great may have been the intellectual triumphs of the nineteenth century, we can hardly think so highly of its achievements as to imagine that, in somewhat less than twenty years, we have passed from complete ignorance to almost perfect knowledge on two such vast and complex subjects as the origin of species and the antiquity of man.

THE SO-CALLED "CONFLICT OF SCIENCE AND RELIGION."[1]

By Principal J. W. DAWSON,
of mcgill university.

IT may be objected that, by the introduction of a cosmogony, the Bible exposes itself to a conflict with science, and that thereby injury results both to science and to religion. This is a grave charge, and one that evidently has had much weight with many minds, since it has been the subject of entire treatises designed to illustrate the history of this conflict or to explain its nature. The revelation of

[1] Extract from a work preparing for publication.

God's will to man for his moral guidance, if necessary at all, was necessary before the rise of natural science. Men could not, more especially, do without some knowledge of the unity of God and the unity of Nature until these great truths should be worked out by scientific induction. Perhaps they might never have been so worked out; therefore, a revealed "book of origins" has a right to precedence in this matter. Nor need it in any way come into conflict with the science subsequently to grow up. Science does not deal so much with the origin of Nature as with its method and laws; and all that is necessary on the part of a revelation to avoid conflict with it is to confine itself to the statement of phenomena and to avoid hypotheses. This is eminently the course of the Bible. In its cosmogony it shuns all embellishments and details, and contents itself with the fact of creation and a slight sketch of its order; and the sacred writers in their subsequent references to Nature are strictly phenomenal in their statements, and refer everything directly to the will of God, without any theory as to secondary causes or relations. They are thus decided and positive on the points with reference to which it behooves revelation to testify, and non-committal on the points which belong to the exclusive domain of science.

What, then, are we to say of the imaginary "conflict of science and religion" of which so much has been made? Simply, that it results largely from misapprehension and misuse of terms. True religion, which consists in practical love to God and to our fellow-men, can have no conflict with true science. They are fast allies. The Bible, considered as a revelation of spiritual truth to man for his salvation and enlightenment, can have no conflict with science. It promotes the study of Nature, rendering it honorable by giving it the dignity of an inquiry into the ways of God, and rendering it safe by separating it from all ideas of magic and necromancy. It gives a theological sanction to the ideas of the unity of Nature and of natural law. The actual conflict of science, when historically analyzed, is fourfold: 1. With the Church; 2. With theology; 3. With superstition; 4. With false or imperfect science and philosophy. Religious men have, no doubt, from time to time identified themselves with these opponents, but that is all; and much more frequently the opposition has been by unwise or bad men, more or less, it may be, professing religious objects.

Organizations styling themselves "the Church," and whose warrant from the Bible is often of the slenderest, have denounced and opposed new scientific truths, and persecuted their upholders; but they have just as often denounced the Bible itself, and religious doctrines founded on it.

Theology claims to be itself one of the sciences, and as such it is necessarily imperfect and progressive, and may at any time be more or less in conflict with other sciences. But theology is not religion,

and may often have very little in common either with true religion or with the Bible. When discussions arise between theology and other sciences, it is only a pity that either side should indulge in what has been termed the *odium theologicum*, but which is unfortunately not confined to divines.

Superstition, considered as the unreasonable fear of natural agencies, is a passive rather than an active opponent of science, except when it becomes affected with some cruel panic. But revelation which affirms unity, law, and a Father's hand in Nature, is the deadly foe of superstition; and, as a matter of fact, no body of people who have been readers of the Bible, and imbued with its spirit, have been found ready to molest or persecute science. Work of this sort has been done chiefly by the ignorant and superstitious votaries of systems which detest the Bible as much as they dislike science.

Perhaps the most troublesome opposition to science, or rather to the progress of science, has sprung from the tenacity with which men hold to old ideas. These, which may at one time have been the best science attainable, root themselves in the general mind, in popular literature, in learned bodies, and in educational books and institutions. They become identified with men's conceptions both of Nature and religion, and modify their interpretations of the Bible itself. It thus becomes a most difficult matter to wrench them from their hold, and their advocates are too apt to invoke in their defense political, social, and ecclesiastical powers, and to seek to support them by the authority of revelation, even when this, rightly understood, might be quite as favorable to the newer views.

All these conflicts are, however, necessary incidents in human progress, which comes only by conflict; and there is reason to believe that they would be as severe in the absence of revealed religion as in its presence, were it not that the absence of revelation seems often to produce a fixity and stagnation of thought, unfavorable to any new views, and consequently to some extent to any intellectual conflict. It has been, indeed, to the disinterment of the Bible, the Reformation of the fifteenth century, that the world owes, more than to any other cause, the rapid growth of modern science, and the freedom of discussion which now prevails. The Bible is surely to be regarded as a religious book, and a very old one. Yet, its constant appeal to the individual judgment in matters of religion exposes it quite as often as science to the attacks of ecclesiastical power, and gives to those who rely on it as a rule of faith a mental stimulus which is to this day the strongest guarantee that we possess for intellectual liberty in other matters.

ASTRONOMY IN AMERICA.

By RICHARD A. PROCTOR.

DURING my visits to America in 1873–'74 and 1875–'76, I was led from time to time to notice with interest the progress and promise of astronomical science in America. My own special purpose in visiting America on these occasions partly brought these matters to my attention. The circumstance that in a country so much more thinly peopled than Great Britain it should be possible not only to obtain audiences for lectures on such a subject as astronomy, but to obtain more and better and larger audiences by far than could be obtained during a lecture-season in England for any single scientific subject whatever, appeared to me in itself sufficiently remarkable. At a first view this might have been referred simply to the fact that the Americans are a lecture-loving people, preferring the quick and ready method of learning the more striking facts of a subject from a verbal exposition to close study and application. But I soon perceived that something more than the mere desire for superficial knowledge was in question. The number of persons making close inquiry into the subject was nearly always greater (even in proportion to the much greater audiences) than in England. That still more select section of every audience, the actual workers and observers, I also found to be correspondingly large; while again and again I met with what in England is certainly very unfrequent—cases, namely, in which persons, not engaged professionally in the study or teaching of astronomy, had privately worked so zealously and so ingeniously in astronomical research as to have effected original discoveries of considerable interest.

I do not propose, however, to enter here into an account of these experiences of my own. To do so would indeed be a welcome task to me, as enabling me in some degree to express not only my sense of the interest taken by Americans in science, but also my recognition of the unvarying kindness with which I was personally received. At Boston, New York, Philadelphia, Washington, Brooklyn, St. Louis, Cincinnati, Baltimore, Chicago, Columbus, Louisville, and Minneapolis, and, in fact, at all the cities and towns which I visited, I received a generous and kindly welcome from the community, accompanied by acts of personal kindness from individuals, which I shall always hold in grateful remembrance. But this would not be the place to attempt the task—in any case no easy one—of expressing my sense of American kindness and hospitality. My present purpose is to indicate simply the remarkable progress made by Americans in astronomical science during the last half-century.

Fifty years ago there were few telescopes and no observatories in

America. It was not greatly to be wondered at that the nation should not up to that time have given any great degree of attention to scientific matters. The proportion of the population having leisure for scientific and especially for astronomical research was but small, and the Government had matters of more vital importance than to attend to the erection of observatories. For several years the attention of Congress had been called to the necessity of a national observatory, but when President Adams, in 1825, made a special appeal to this effect, his proposal met with ridicule and disfavor.

The first action toward the initiation of astronomical research in America bears date March, 1810, when it was proposed in Congress (by Mr. William Lambert, of Virginia) that a first meridian should be established for the United States (the meridian of the Capitol at Washington being selected), in order to obviate the "confusion already existing in consequence of the assumption of different places within the United States as first meridians, on the published maps and charts" in the country. The proposition was at once acted upon. In July, 1812, we find Mr. Monroe, then Secretary of State, indicating its astronomical bearing. "In admitting," said he, "the propriety of establishing a first meridian within the United States, it follows that it ought to be done with the greatest mathematical precision. It is known that the best mode yet discovered for establishing the meridian of a place is by observations of the heavenly bodies; and that, to produce the greatest accuracy in the result, such observations should be often repeated, at suitable opportunities, through a series of years, by means of the best instruments. For this purpose an observatory would be of essential utility. It is only in such an institution, to be founded by the public, that all the necessary implements are likely to be collected together, that systematic observations can be made for any great length of time, and that the public can be made secure of the results of the labors of scientific men. In favor of such an institution it is sufficient to remark that every nation which has established a first meridian has also established an observatory." Mr. Lambert brought in a bill proposing the erection of such an observatory in 1813; but nothing more was done until 1815, when the memorial on which the bill of 1831 had been based was referred to a select committee. No steps were then taken, however, to carry a bill. In November, 1818, a third memorial from Mr. Lambert was presented, and referred to a select committee; but the resolution asked for was not finally passed until March 3, 1821, when Mr. Lambert was appointed by the President "to make astronomical observations by lunar occultations of fixed stars, solar eclipses, or any approved method adapted to ascertain the longitude of the Capitol from Greenwich." In December, 1823, Mr. Lambert, in a report of his labors, gave for the longitude of the Capitol 76° 55′ 30″.54, closing his report with a strong appeal for the erection of an observatory.

Two years later, President Adams urged on Congress the establishment of a national observatory as part of a wider scheme for the advancement of knowledge. His remarks on the astronomical portion of his scheme serve well to show the position of astronomy in America half a century ago. "Connected with the establishment of a university," he says, "or separate from it, might be undertaken the erection of an astronomical observatory, with provision for the support of an astronomer to be in constant attendance on the phenomena of the heavens, and for the periodical publication of his observations. It is with no feeling of pride as an American that the remark may be made that, on the comparatively small territorial surface of Europe, there are existing more than one hundred and thirty of these lighthouses of the skies, while throughout the whole American Hemisphere there is not one. If we reflect for a moment upon the discoveries which in the last four centuries have been made in the physical constitution of the universe by means of these buildings, and of observers stationed in them, shall we doubt of their usefulness to every nation? And while scarcely a year passes over our heads without bringing some new astronomical discovery to light, which we must fain receive at second-hand from Europe, are we not cutting ourselves off from the means of returning light for light, while we have neither observatory nor observer upon our half of the globe" (!) "and the earth revolves in perpetual darkness to our unsearching eyes?"

In March, 1826, a bill "to establish an observatory in the District of Columbia" was brought before Congress and read the first and second time, but the House journals show no further trace of it. This bill was due to the recommendations of Mr. Adams, who did not relax in his efforts to secure the erection of a national observatory, though delays and disappointments occurred which might well have exhausted his energy, seeing that the dates of his renewed and for a while useless appeals were 1836, 1838, 1840, and 1842.

Passing over many circumstances in the history of these transactions, not as being without interest, but because space will not permit of their being presented here, we may proceed to the time when the actual erection of the buildings was commenced. This was in 1843, or no less than thirty-three years after the plan for an observatory was first proposed, so that fully one-half of the period which has elapsed since Lambert, of Virginia, first called his countrymen's attention to the necessity of establishing a national observatory was lost in discussions and delays. At the close of September, 1844, the new building was ready for occupancy, and the instruments were adjusted.

From 1844 to 1861 the Washington Observatory was under the superintendence of Lieutenant Maury. In September, 1846, the first volume of "Observations" was issued. Its value has been thus described by an impartial and competent judge: "Besides a fair amount of observations with the two transit instruments in the meridian and

the prime vertical, and those with the mural circle, it contained various important investigations of the errors and corrections peculiar to the instruments. Prof. Coffin's masterly discussion of the adjustments of the mural circle, and his expansion of Bessel's Refraction Tables, Walker's investigation of the latitude of the observatory, and his comparison of the standard thermometers; all of great value."

In the second volume reference was made to the discovery of Neptune, and the success of Mr. Walker, one of the assistants, in detecting, among Lalande's observations, two of Neptune, on May 8 and 10, 1795, when the planet was observed and recorded as a fixed star. "Astronomers were thus furnished with an observation of Neptune made fifty-two years before, which afforded the means of a most accurate determination of the orbit, and enabled the superintendent of the *American Nautical Almanac* to publish an ephemeris of the new planet two years in advance of all other parts of the *Almanac. The observatory was first brought into prominence by these researches.*" In October, 1849, Lieutenant (now Rear-Admiral) Davis wrote as follows to the Hon. Secretary of the Navy on this subject: "The theory of Neptune belongs, by right of precedence, to American science. In connection with its neighbor, Uranus, it constitutes an open field of astronomical research, into which the astronomers and mathematicians of the United States have been the first to enter, and to occupy distinguished places." Deprecating heartily though I do, all reference to priority or nationality in such matters as opposed to the true scientific spirit, I cannot but note how Prof. Newcomb, by his admirable researches into the theory of Uranus and Neptune, has fulfilled the hopes thus expressed nearly a quarter of a century before his labors were brought to a successful termination.

The work of the observatory, thus happily inaugurated, was prosecuted steadily till 1861, when Commander Maury left Washington to join the cause of the Confederate States. During the greater part of the war the observatory was under the charge of Captain Gilliss, who died on February 9, 1865. "It has been noted as a strange coincidence of circumstances," says Prof. Nourse, in the memoir of the observatory from which we have been quoting, "that the last morning of his life witnessed an announcement of results deduced at this observatory which had fulfilled his long-deferred hope of determining the solar parallax by simultaneous observations in Chili and in the United States. This announcement would have been peculiarly gratifying to him because these results were from the joint activity of the two observatories, founded through his exertions, 5,000 miles apart."

From 1865 to 1867 the observatory was under the superintendence of Rear-Admiral C. H. Davis, and from 1867 to the present time it has been under that of Rear-Admiral B. F. Sands. Without further considering the work accomplished at the observatory itself, which

has partaken of the general character of official astronomical research, we may consider here some of the special astronomical occasions at which the observers trained at Washington have assisted.

The total eclipse of August 7, 1869, was closely observed by parties from the observatory. Prof. Asaph Hall and Mr. J. A. Rogers proceeded to Alaska; Profs. Newcomb, Harkness, and Eastman, to Iowa; and Mr. F. W. Bardwell, to Tennessee. The observations made on this occasion were of great value and interest. The solar prominences had had their real nature determined during the eclipse of August, 1868; and the American observers were not content to repeat the observations then made, but extended the method of spectroscopic analysis to the corona. They also obtained photographs of the colored prominences. The work accomplished by the Washington observers, together with the observations made by Dr. Curtis, Mr. J. Homer Lane, of Washington City, Ind., and Mr. W. S. Gilman, Jr., of New York, and General Myer, U. S. A., form a quarto volume of 217 pages, with twelve illustrations. Of this valuable and interesting volume, 3,500 copies were printed by joint resolution of Congress.

The superintendent of the Washington Observatory was not content with this. "Believing that the experience of its officers in their observations of the eclipse of 1869 should be availed of for the further elucidation of the subjects involved in such phenomena, he addressed the Navy Department upon the subject of their employment in Europe in observing the eclipse of December, 1870; the department promptly detailed the professors who had been the observers of the previous year;" and it was doubtless through the energy thus displayed by Rear-Admiral Sands that other skillful American astronomers were enabled to cross the Atlantic for the purpose of observing that important eclipse. Unfavorable weather prevented observations of this eclipse at some of the best stations, but the American observers succeeded in establishing the accuracy of the observations made in 1869, and to them must be attributed in large part the definite demonstration of the fact, which though now admitted was then much disputed, that the corona is a solar phenomenon, and not due to the illumination of our own atmosphere only.

The part taken by the Washington Observatory in preparing for and coöperating in the observation of the transit of Venus, on December 8, 1874, is too recent to need full description in this place. I may be permitted, however, to dwell with special commendation on the manner in which American astronomers devoted themselves at that time to a task which they might fairly have thought the business of their European brethren. A transit of Venus is to occur in 1882 which will be specially American, being visible wholly or in part from every portion of the United States; and, if America had reserved her energies for that occasion, no complaint could reasonably have been

made. It was indeed the prevalent idea in Europe that that would be the course she would adopt. But, with singular generosity and scientific zeal, she not only devoted to the work of observing the earlier transit a sum largely exceeding the amount granted by any other government (and nearly twice as large as Great Britain paid), but undertook some of the most difficult portions of the work, which otherwise would have been left unprovided for. I cannot but recall with a feeling of something like personal satisfaction (though conscious that such a feeling ought to find no place in the mind of the true student of science), the gratification with which I welcomed the announcement, early in 1873, that America had undertaken to occupy positions, the importance of which I had long pointed out, but which, but a fortnight before that announcement reached Europe, had been confidently described as astronomically inferior and geographically unsuitable. The pleasure I then felt was only surpassed by that which I experienced subsequently, when news received from the various observing stations showed that at those just mentioned were achieved some of the most important successes of the occasion.

Another noble contribution made to science at Washington has been the erection of the splendid refractor 26 inches in aperture, which is now the chief equatorial of the observatory. America is fortunate in possessing in Alvan Clark the greatest living master of the art of constructing large object-glasses of good definition. He had already constructed a telescope 18 inches in aperture for the observatory at Chicago, but by the contract negotiated with him in August, 1870, by Prof. Newcomb, he was called on to achieve a far more difficult task in the construction of a telescope of 26 inches clear aperture. He has successfully accomplished this task, and the telescope has already obtained good results under Newcomb's skillful management. The most important of these is an extensive series of observations of the satellites of Uranus and Neptune, made with a view of determining the elements of their orbits and the masses of the planets round which they circle. The observation of the two Uranian satellites, Ariel and Umbriel, discovered by Lassell, and of the Neptunian satellite also discovered by him, must be regarded, on account of the extreme difficulty of observing these bodies, as a very valuable contribution to astronomy. It is pleasant to notice that Newcomb has been able most thoroughly to confirm the accuracy of Lassell's work in Malta, the mean motions of Ariel and Umbriel deduced from the Malta observations being so accurate that, says Newcomb, "they will probably suffice for the identification of those objects during several centuries." Although no systematic search has been made for new satellites of Uranus, yet enough has been done to show, "with considerable certainty," that at least the outer satellites supposed to have been seen by Sir W. Herschel "can have had no real existence" (as satellites. that is to say).

Before passing to the brief consideration of the work accomplished in some of the other American observatories, we must fully admit the justice of the remarks made by Prof. Nourse in closing his memoir relating to it. "The position now accorded to it," he says, "by the free tributes of scientific men in the Old World as well as at home, is not without honor to our country; and this notwithstanding the comparatively recent founding of the institution, and the as yet limited appropriations sustaining it. It may, therefore, justly claim a yet more generous support; and the pledge may be safely made that, if thus supported and efficiently directed, it will make returns yet more gratifying to national pride, and (which is a matter infinitely more important) advancing the highest aims of scientific research. What shall be its future records of success must remain with the support extended by the government and the fidelity of those who are intrusted with its administration."

The actual commencement of astronomical observation in America belongs to a much earlier period than that at which the Washington Observatory was erected. The first telescope used for astronomical purposes in America was set up at Yale College forty-six years ago. The first observatory, however, properly so called, was erected at Williams College, Massachusetts, in 1836. The next was the Hudson Observatory, established in connection with the Western Reserve College, Ohio, under the charge of Prof. Loomis (now of Yale), whose works on astronomy are deservedly held in high esteem in this country as well as in America. The next in order of time came the Observatory of the High School at Philadelphia, which achieved distinction under the able management of Messrs. Walker and Kendall. The West Point Observatory was next established, and placed under the care of Prof. Bartlett. All these preceded the Washington Observatory.

Soon after the Washington Observatory had been erected, an observatory was built at Cincinnati. Its history illustrates well the way of carrying out such work in America, when the Government does not take the work in hand. The idea of erecting an important observatory in Cincinnati was first entertained by Prof. Mitchel, then Professor of Mathematics at Cincinnati College. He proposed to attempt the task without any aid from the General or State Government, by the voluntary contribution of all classes of citizens. To ascertain whether any interest could be excited in the public mind in favor of astronomy, he delivered, in the spring of 1842, a series of lectures in the hall of the Cincinnati College. With truly American ingenuity he devised a mechanical contrivance, by help of which telescopic views in the heavens were presented with a brilliancy comparable with that "displayed by powerful telescopes." These lectures were attended by large audiences, and I may add, in passing, that the interest which they excited is to this day well remembered in Cincin-

nati—no small proof of Prof. Mitchel's power as a lecturer.[1] The last lecture of the course was delivered in one of the great churches of the city (a thorough American and sensible proceeding), and at the close Prof. Mitchel submitted to the audience, consisting of more than two thousand persons, his plan for erecting a first-class observatory, and furnishing it with instruments of the highest order. He promised to devote five years of faithful effort to accomplish this task. The following course was then suggested: "The entire amount required to erect the buildings and purchase the instruments should be divided into shares of twenty-five dollars; every shareholder to be entitled to the privileges of the observatory under the management of a board of control, to be elected by the shareholders. Before any subscription should become binding, the names of three hundred subscribers should be first obtained. These three hundred should meet, organize and elect a board, who should thenceforward manage the affairs of the association." In three weeks the three hundred subscribers had been obtained, without calling any public meeting, and merely by quiet visits in which the nature of the scheme was described and explained. Then officers were elected, a directory formed, and Mitchel was sent "to visit Europe, procure instruments, examine observatories, and obtain the requisite knowledge to erect and conduct the institution, which it was now hoped would be one day reared."

When Mitchel returned, four months later, a great change had occurred in the commercial affairs of America. "Everything was depressed to the lowest point," and it was with great difficulty that a sum of $3,000 was collected and remitted to meet the first payment for the telescope of twelve inches aperture ordered of Merz. The best place for the observatory was a hill-top rising 400 feet above the level of the city. On offering to purchase this from Mr. Longworth, to whom it belonged, Prof. Mitchel was directed to select and inclose four acres, which Mr. Longworth presented to the association. On November 9, 1843, the corner-stone of the pier which was to sustain the great refracting telescope was laid by John Quincy Adams, who undertook the long (and then difficult) journey from Washington to give this proof of his interest in the cause of astronomy. When, in May, 1844, the great telescope was paid for, the funds of the association were exhausted, and the estimated cost of the building amounted to more than $7,000. In this difficulty a simple but again perfectly American plan was followed. Mechanics and others were invited to subscribe for stock in the Astronomical Society, paying their subscriptions with work. In six weeks not less than one hundred hands were at work on the hill-top and in the city. The stone of which the

[1] The same remark applies to the lectures which he subsequently delivered in New York, New Orleans, Boston, Brooklyn, and other large cities. It is almost impossible to over-estimate the service thus rendered by Prof. Mitchel to astronomy in the United States.

building was erected was quarried from the grounds of the society. The lime was burned on the hill, and every means was adopted to reduce unnecessary expenditure. Payment for stock was received in every possible article of trade; due-bills were taken, and these were converted into others which would serve in the payment of bills. In this way the building was reared, and finally covered in, without incurring any debt. But the conditions of the bond by which the lot of ground was held required the completion of the observatory in June, 1845. It was seen to be impossible to carry forward the building fast enough to secure its completion by the required time without incurring some debt. "My own private resources," proceeds Mitchel, "were used in the hope that a short time after the finishing of the observatory would be sufficient to furnish the funds to meet all engagements. The work was pushed rapidly forward. In February, 1845, the great telescope safely reached the city; and in March the building was ready for its reception." Unfortunately, just at this time, when his private means were exhausted, Prof. Mitchel's professorship was brought, in a very summary manner, to a temporary close, in consequence of the college edifice being burned to the ground. To recruit his means without abandoning the cause of astronomy, he gave courses of lectures in the chief cities of the United States, meeting with well-deserved success.

The observatory thus erected achieved useful though not very striking results. An observatory which was erected a year or two later took so quickly the leading position, so far as the actual study of the heavenly bodies was concerned, that the progress of the Cincinnati astronomers, as indeed of most of the astronomers of the United States, received less attention than otherwise might have been the case. I refer to the observatory at Harvard (Cambridge, Massachusetts). Here one of the first equatorials ever made by Merz was erected; and by means of it W. C. Bond, and his son, George P. Bond, made highly-interesting additions to astronomical knowledge. The seventh satellite of Saturn (eighth and last in order of discovery) was detected, the dark ring rediscovered and found to be transparent; important drawings of nebulæ were made, and many other observations were effected, under the administration of the Bonds. Later, under Prof. Winlock, the Harvard Observatory has been distinguished by the excellence of the mechanical arrangements adopted there, and by M. Trouvelot's admirable drawings of solar spots and prominences of the planets Jupiter and Saturn, and of various details of lunar scenery.

In passing, I may note that at Harvard, as indeed elsewhere in America, others than professed astronomers have achieved very useful astronomical work. As Prof. Mayer, of the Stevens Institute, Hoboken, has turned his marvelous ingenuity in devising new methods of physical research to astronomical inquiries, so Prof. Cooke, of Harvard, whose special subject is chemistry, made a most important

astronomical discovery, which has since been ascribed to Janssen, who, later (though independently and by another method), effected it. Prof. Cooke made a series of observations on those bands in the solar spectrum which are due to our own atmosphere, with the object of ascertaining whether they are due to the constant constituents of the air, or to the aqueous vapor which is present in the air in variable quantity. Combining hygrometric with spectroscopic observations, he found that when the air is moist these bands are more clearly seen than when the air is dry, and by systematic observations so definitely ascertained this relation as to prove beyond all manner of doubt that the bands are due to aqueous vapor. Unfortunately, though his results were published in America, they were not published in such a way as to attract notice in Europe, and accordingly European astronomers remained ignorant of the most important fact discovered by Cooke until they had rediscovered it for themselves.

The observatory at Ann Arbor, Michigan, was erected in 1854, chiefly through the exertions of Chancellor Tappan, of the Michigan University. Dr. Brünnow, our present Astronomer Royal for Ireland, was for a long time director of this observatory. It is at present under the able control of Prof. Watson, who has added nearly a score of planetoids to the known members of the solar family.

The observatory of Dartmouth College, Hanover, New Hampshire, illustrates in a remarkable way the energy and zeal with which college-observatories are managed in America. It would be difficult to name any observatory in this country where observations of greater interest, as respects the physics of astronomy, have been made than those effected by Prof. Young with the nine-inch telescope constructed by Alvan Clark for the Dartmouth College; or than the supplementary observations made by Young with a powerful telescope conveyed to an elevated pass in the Rocky Mountains. Among his results may be specially mentioned—first, the observations of the most remarkable solar outburst yet witnessed, an outburst during which the glowing hydrogen of the prominences was driven to a height of at least 200,000 miles from the surface of the sun; and, secondly, the identification of more than 250 lines in the spectrum of the solar sierra.

And as the most interesting and characteristic observations yet made upon solar prominences are due to Prof. Young, of Dartmouth Observatory, so the most accurate and detailed drawings yet made of sun-spots are those by Prof. S. Langley, of the Alleghany Observatory, near Pittsburg.

At Chicago, a very fine telescope, eighteen inches in aperture, by Alvan Clark, has been erected; but, owing to pecuniary difficulties consequent on the great fire (followed by the commercial depression which has recently affected the United States), that observatory has suffered considerably from the want of a properly remunerated director. The Astronomical Society of Chicago has done its best to set

matters straight, but differences have arisen which have marred their efforts. In the mean time, Mr. S. W. Burnham, of Chicago, has shown admirable zeal and skill in the systematic observation of double stars, having discovered and measured more than 450 of these objects (all of a delicate and difficult nature).

But, indeed, it would be hopeless to attempt, in the short space available to me here, to give any sufficient account of the labors of American astronomers, whether attached to Government or State observatories, or working independently. Of the latter, and in my opinion not the least important class, I need cite only Drs. Rutherfurd and H. Draper, the former of whom, besides making other extremely important contributions to astronomy and physics, has produced celestial photographs admittedly better than any obtained on this side of the Atlantic; while the latter at an earlier period achieved results in celestial photography which were far superior to any obtained at that time, or for many subsequent years. The advice and assistance rendered by Dr. H. Draper to the astronomers to whom were intrusted the preparations for the recent transit, were most deservedly commemorated in a medal which the American Government honored itself by awarding to him.

The most striking feature in the contributions made by Americans to astronomy appears to me to be the skill shown in noting the essential points to be aimed at, and the fertility and readiness of resource exhibited as the work proceeds. In England, students of astronomy are too much in the habit of following conventional rules, and wasting time over unnecessary preliminaries. An American astronomer notes that some particular observation is wanted, and directs his efforts to making that observation, not considering it necessary in the first place to go over ground already repeatedly traversed by others.

I have been sometimes asked whether officialism is as rampant in America as in England in matters scientific. American scientific officials have assured me that it is, or rather (for they have not worded the matter precisely in that way) they hold that official science is properly (as they consider) paramount in their country. I was gravely assured in Washington, for instance, that the course which I had pursued in England, with reference to the suggested official schemes for observing the transit of Venus in 1874, would never have been tolerated in America, despite the fact that the course actually followed by American official science was precisely that which I had advised. It was the *principle*, so an eminent American official scientist assured me, which was in question, and no American would have been suffered to oppose as I did the course advised by the chief official astronomer. What would have happened to such an unfortunate was not clearly indicated; and I must confess that all I heard outside official scientific circles in America suggested to me that any mistake made by official science would be commented upon even more freely

in America than in England, and quite as safely. In fact, I had reason to believe that the warmth of my own welcome in America was in no small degree due to the fact that, having first proved the justice of my views, I had not been afraid to maintain them publicly against the powers that were until the proper course was adopted.

One other point remains to be noticed, the influence, namely, of religious scruples upon scientific progress and research in America. Here I must admit that I was somewhat disappointed. I expected to find America a long way in advance of England. But with some noteworthy exceptions, especially in the West, America seems to me to be behind England in this respect. It is only here and there, in England—in the Bœotian corners, so to speak, of this country—that the community opposes itself to advanced scientific ideas to the same extent as in some of the leading cities of the United States. This is partly due to two opposite influences: the Puritan element of the American population on the one hand, and the Roman Catholic element on the other. Progress, however, is being steadily made in this as in other matters. Indeed, it has been rather because America began later to bestir itself in the encouragement of free search after truth that she is at present behind England in this respect. Judging from experience in other matters, she will move rapidly now her progress has begun, and will soon occupy the position to be expected from the natural freedom and independence of the American mind. It need hardly be said that in America, as in Europe, such contest as arises from time to time between religion and science has its origin entirely from the side of religion. There as here religion (so called) attacks and denounces discoveries inconsistent with the views which the orthodox had been accustomed to advocate; and there as here, when there as no longer any choice, the orthodox quietly accept these discoveries as established facts, expressing a *naïve* astonishment that they should ever have been thought in the least degree inconsistent with received opinions.—*Advance-sheets of Popular Science Review.*

IS THE DEVELOPMENT HYPOTHESIS SUFFICIENT?

By Dr. JAMES McCOSH,
PRESIDENT OF PRINCETON COLLEGE.

THIS paper has been occasioned by the lectures of a distinguished Englishman who has visited this country; but I am to keep very much to my general subject, and not enter upon a minute criticism of Prof. Huxley. In these lectures he has abstained from entering on those exciting topics bearing on materialism and religion, which he has discussed so freely in Edinburgh and in Belfast, and in his published writings. So far the hopes of unbelievers in Scripture, and the fears

of timid Christians, and the rising rage of polemic theologians, have been disappointed. But an interest has been excited in the subject of development. In the present state of the public mind, good may arise from showing that when the doctrine of development is properly explained and understood, and kept within its legitimate sphere, there is nothing in it inconsistent with natural or revealed religion; and that the scientific truths which Prof. Huxley has expounded in these lectures do not entitle him to draw the consequences which he has done in his "Lay Sermons" and other writings.

In his first lecture the professor had light work and an easy victory. He set up two targets and shot them down. He stated and overwhelmed two hypotheses: the first, that Nature has been all along very much in the same state as it now is; and the second, the poetical account given by Milton in "Paradise Lost." It did not need an Englishman to come 3,000 miles, it did not require a man of Prof. Huxley's knowledge and dialectic skill, to demolish these fancies. I cannot remember a single man eminent in science, philosophy, or theology, defending either of these views during the last half-century. The first hypothesis was never held by religious men, though it has been defended by a few scientific men—who might have been kept from error by looking to Scripture—such as Hutton, Playfair, and Lyell in his earlier writings. The book of Genesis speaks of an order and a progression in the origination of things and of a flood covering the then peopled earth. I should not expect any one but a Don Quixote to attack Milton's exposition of a popular belief. The view given in "Paradise Lost" was not the one entertained by several of the most eminent of the Christian fathers, such as Origen, and has not been entertained by any theologian of ability and scholarship for the last age or two. It must now be forty or fifty years since Chalmers and Pye Smith and certain well-known divines of the Church of England, and President Hitchcock of Amherst, adopted the discoveries of geology and sought to reconcile them with Scripture. It is an instructive circumstance that, while Milton's account cannot stand a moment's investigation, the record in Genesis is believed by many of our highest men of science to be perfectly consistent with the latest science. I name only Prof. Dana, Prof. Guyot, and Principal Dawson, the highest authorities on this continent, and superior to Prof. Huxley, not certainly in zoölogy, but in geology. I am quite ready to give up these two hypotheses to Prof. Huxley, to hew and hack them (to use one of his own phrases) like Agag.

The second lecture is written in his best manner. There is scarcely anything in it that I am inclined to object to. He is no longer killing hypotheses which died a natural death long ago. He is arranging his materials for the defense of the theory of Evolution. He has as yet only brought forward the cases which he acknowledges are not demonstrative of the truth of evolution, but are such as must exist if

evolution be true, and which, therefore, are upon the whole strongly in favor of the doctrine of development. He makes a number of admissions. He allows that there are species which have continued unchanged, not only throughout all historical years, but all geological ages. Cuvier has shown that the ibises, dogs, and cats depicted 3,000 years ago or more on the monuments of Egypt are the same as those found in that country in the present day. The professor mentions a fish of the chalk formation named cericus, which is represented at the present day by a very closely-allied species living in the Atlantic and Pacific Oceans. He thence argues that there is no intrinsic necessity in animal forms to change and to advance, as some sciolists assume. But he labors to prove that there are cases in which varieties have become species by reason of being suited to their surroundings. He gives credit to Mr. Darwin for bringing in two great factors in the process of evolution: "One of them is a tendency to vary, the existence of which may be proved by observation in all living forms; and the other is the influence of surrounding conditions upon what I may call the parent form, and the variations which are thus evolved." He adds: "The production of variations is a matter *not at all properly understood at present.* Whether it depends on some secret machinery —if I may use the phrase—of the animal form itself, or whether it arose from the influence of conditions upon that form, is not certainly a matter for our present purpose." True, this may not be for the purpose of his lecture, but it must be cleared up before we can clear up the subject of development. The nature and laws of variations and the peculiar laws of heredity are at present shrouded in mystery. When we know more of them and of the forces at work, we shall be in a better position to determine whether varieties ever do become distinct species.

The professor acknowledges that geology does not furnish decisive evidence of one form of life passing into another. But then he claims that the geological record is not complete; that much of what is written in stone has been effaced, and that if it were complete it would show us the missing links. To equal him in candor I admit that transitional forms are ever casting up. He shows that in certain fields we have those transitions already disclosed. He dwells on the resemblances and the affinities between reptiles and birds, and refers to animals which have some of the properties of both. Thus there are birds that have teeth, and reptiles that have wings and can stand on their two hind-legs, such as the *hadrosaurus* found in New Jersey. His demonstration, as against Owen, seems to me complete here. True, there are naturalists who maintain that the teethed bird is still a bird, and the archeoptrix a reptile, a variety and not a transitional form. Still, such cases indicate a tendency on the part of the reptile to rise to the bird, and of the bird to retain properties of the reptile; and natural selection and development alone can explain this.

In his third lecture he brings forward what he regards as a demonstration. In the case of *Equus*, embracing our horse, ass, and zebra, he is able, by means of the specimens gathered in the West by Prof. Marsh, to discover the succession of horse-like forms which the hypothesis of evolution supplies. He goes back from the living horse through the like animals of the post-Tertiary in the Pliocene, middle, and earlier on to the older Eocene formation, where he finds the orohippus. "There you have four toes on the front-limb complete, three toes on the hind-limb, a complete and well-developed ulna getting forward an equality of size with the radius, a complete and well-developed fibula apparently, though it is not quite certain, and then teeth with their simple fangs. So that you are now able, thanks to these researches, to show that, so far as our present knowledge extends, the history of the horse-type is exactly and precisely that which could have been predicted from a knowledge of the principles of evolution, and the knowledge we now possess justifies us completely in the anticipation that, when the still older Eocene deposits and those which belong to the Cretaceous epoch have yielded up their remains of equine animals, we shall find first an equine creature with four toes in front and a rudiment of the thumb, then probably a rudiment of the fifth behind, and so, by gradual steps, until we come to that five-toed animal in which most assuredly the whole series took its origin. That is what I mean, ladies and gentlemen, by demonstrative evidence of evolution."

Suppose that we admit all that the lecturer claims on this subject: what then? Have we thereby set aside any doctrine of philosophy or religion? The Christian, even the Christian theologian, may say wisely: "Let naturalists dispute as they may about the derivation of plants and of the lower animals; their hypotheses, arguments, and conclusions, do not interfere with our belief that God is to be seen everywhere in his works and rules over all." It appears to me that the whole doctrine of vegetable and animal species needs to be reviewed and readjusted—and religion need not fear the result. I have been convinced of this ever since I learned, when I was ardently studying botany, that the number of species of plants had risen to two millions! I was sure that all these are works of God; but I was not sure that each was a special creation.

When a new truth is discovered, especially when it is a reaction against an old theory, it is apt to bulk so largely in the view of those who hold it that they carry it to extreme lengths, and it requires time and discussion to confine it to its own place. Thus, in old time, Thales perceiving how much water could do, and Anaximenes how much air could accomplish, and Pythagoras how much numbers and forms could account for, hastened to the conclusion that the whole operations of Nature could be derived from them and explained by them. I am old enough to remember that the brilliant discoveries of

Sir Humphry Davy led wandering lecturers and all sorts of sciolists to affirm that they could explain all things, matter and mind itself, by electricity. So, in these days, development, having furnished a key to open so many of the secrets of Nature, has led some to imagine that it can solve all the mysteries of the universe. Some of us may be inclined to admit, and to use for scientific purposes, the doctrine of development, and yet be prepared to deny that it can explain everything. The fact is, it overlooks a great many more things than it notices. There are signs of a reaction among scientific men against its extreme positions; and it is the work of the age now present to show how much development can do, and how much it cannot do. Even Darwin is obliged to call in a few germs created by God, and a pangenesis in order to account for development. Herbert Spencer acknowledges a great Unknown behind visible phenomena. Huxley recommends a worship chiefly "of the silent sort." Religion comes to them and says, "Whom, therefore, ye ignorantly worship him declare I unto you."

In the common apprehension of those who hold the development hypothesis, all that is necessary to account for the world in its present state is to suppose that millions of years ago there appeared—no one can tell how—a nebulous mass with an inconceivably high temperature, but losing its heat and ready to condense; that in the long lapse of time it took the shape of planets, satellites, and sun; and that on one of these planets—that on which we dwell—it formed into plants, animals, and finally man, all by its own power, according to natural law, or, rather, the necessity of things, without it being necessary to call in a God or a guiding providence, or to suppose that there has been a plan in a designing mind. All the defenders of the theory do not state this in express words, but it is the impression left by their expositions, though some of them, such as Herbert Spencer and Tyndall, would save themselves from the blank consequences by calling in an unknown and unknowable power beyond the visible phenomena, or by appealing to some religious feelings supposed to be deep in our nature, but which the theory would soon undermine, as being, in fact, unjustifiable and unreasonable. This is the view that I mean to meet. In examining this hypothesis there are some things which I am willing to admit as being established truths:

1. I hold the doctrine of the Conservation of Force—that is, that the sum of energy, real and potential, in the universe is always one and the same, and cannot be increased or diminished by human or mundane action. I was prepared for this doctrine when it was announced by Mayer, of Heilbronn, and by Joule, of Manchester, and expounded by Grove, of London. It seemed to me to follow from the doctrine which I had laid down in my first work—"The Method of Divine Government"—published twenty-six years ago: as to the material universe being composed of substances with properties or pow-

ers of which it cannot be deprived, and which cannot be added to nor lessened. It is this that secures the permanence of Nature, keeping it unchanged in its power or powers amid all changes of action. This energy, disappearing in one form, appears necessarily in another, and gives us what Spencer calls the "persistence of force." This ever-enduring force gives rise to development. Going out from one body, it is manifested in another. The fact is, all causation, all physical action, is evolution. The substances and powers in the agents acting as the cause are found, though in a modified form, in the effects. Proceeding on this very principle, Mayer says: "Forces are causes; accordingly, we may in relation to them make full application of the principle *causa equat effectum*," and he thus elaborated the grand scientific truth, the most important discovered in our day, that the sum of energy in the universe is always the same.

2. I admit that this power becomes more and more differentiated, that is, takes more and more diverse forms, and thus imparts an ever-increasing multiplicity and variety to the universe, and will continue to do so till the diversity breaks it up, and "the heavens shall pass away with a great noise, and the elements shall melt with fervent heat, the earth also, and the works that are therein shall be burned up." Mr. John S. Mill has been successful in showing that there is usually more than one antecedent or agent in a cause. "A man takes mercury, goes out-of-doors, and catches cold. We say, perhaps, that the cause of his taking cold was exposure to the air. It is clear, however, that his having taken mercury may have been a necessary condition of his catching cold; and though it might consist with usage to say that the cause of his attack was exposure to the air, to be accurate we ought to say that the cause was exposure to the air while under the effect of mercury." He concludes, "The real cause is the whole of these antecedents." Now, I hold that in physical Nature causes are not only usually, but invariably, of this dual or plural nature. I go a step farther, and have shown, I think, that the effects are also of the same dual or plural character. The effect, in fact, consists of the same agents or substances as the cause, but now in a new state. A picture falls from a wall and breaks a table; we say that the breaking of the table was the effect of the fall of the picture. But the true effect embraces both the picture and the table, the picture having lost its momentum, and the table being broken. It follows from all this that the new combination of agents, acting as the causes, must produce more and more varied effects, as the effects joining with other effects become causes, and ramify into branches and branchlets. The sum of the powers is one and the same, but they appear in an ever-increasing number and diversity of forms. The conservation of force thus gives a unity to Nature, while the mutual action and interaction give it its multiplicity. I remember how deeply I was interested in that paper (I read it when it appeared) of Von Baer, in which he shows

that in the germs of animals, as in the history of the production of animated Nature through long ages, there are first greater unity and simplicity, and then specific varieties more and more divergent.

3. I have never set myself, as too many religious men unwisely did, against the theory, first started, it would appear, by Kant, then elaborated by Sir William Herschel and Laplace, and perfected, I believe, by a professor in Princeton College, that the mundane system may have been formed out of original matter, evolved according to the mechanical laws with which it is endowed—first the outer planets, then the inner, and finally the sun condensed into the centre. This never appeared to me to be an irreligious doctrine, though Laplace was unhappily a man without religion.

4. Once more, I have ever stood up for a doctrine of Development. There is a development of one form of matter from another, of one force from another. There is, as every one allows, a development of the plant and animal from the parent. I see nothing irreligious in holding that the bird may have been evolved by numerous transitions from the reptile, and the living horse the old horse of the Eocene formation. An accumulation of powers, new conditions and surroundings may, it is acknowledged, produce a variety which may become hereditary. Let us suppose that they can also, in rare cases of combination, produce species: religion is not thereby undermined, either in its evidences or in its essential doctrines.

The question now arises and presses itself upon us: Can we by these acknowleged agencies explain the whole of the present state of the universe, with all its fitnesses, its harmonies, its beauty, its utility, its beneficence? The development theory, in the narrow and exclusive form which it commonly takes, overlooks vastly more than it notices. In particular, there are four grand truths kept out of sight. Without these, we cannot understand the Cosmos. When these are introduced, they bring God into his own universe, and fill it with life and love.

1. *God is present in all his Works, and acts in all their Actings.*—This is the religious doctrine. "By him all things consist." Paul, addressing the men of Athens, said: "For in him we live, and move, and have our being; as certain also of your own poets have said, For we are also his offspring." This doctrine may be so stated as to make it pantheistic. It is the one grand truth contained in pantheism, giving it all its plausibility, and making it superior to that bald theism which makes God create the world at first, and then stand by and see it go. The doctrine can be so stated as to free it from all such tendencies on the one side or the other, so as to make God distinct from all his works, and yet acting in them. This is, I believe, the philosophical doctrine. It has been held by the greatest thinkers which our world has produced, such as Descartes, Leibnitz, Berkeley,

Herschel, Faraday, and multitudes of others. It seems to be required by that deep law of causation which not only prompts us to seek for a cause for everything, but an adequate cause, to be found only in an intelligent mind. Our greatest American thinker, Jonathan Edwards (whom I can claim as my predecessor), maintains that, as an image in a mirror is kept up by a constant succession of rays of light, so Nature is sustained by a constant forth-putting of the divine power. In this view Nature is a perpetual creation. God is to be seen not only in creation at first, but in the continuance of all things. "They continue to this day according to thine ordinances." He is to be acknowledged not only in the origination of matter, but in its developments; not only in the reptile and the bird, but it may be in the steps by which the one has been derived from the other; not only in the orohippus, but in the stages by which that animal has risen into the horse so useful to man.

2. *New Powers appearing in Nature.*—Let us suppose that there was an original matter. I regard it as most in accordance with the principles of our reason to ascribe that matter to God. What properties had that matter at first? Every man of ordinary wisdom and modesty will be ready to answer, "I know not." If he does not know, he is not entitled to say that all things have proceeded from it. I suppose it will be allowed that it possessed gravitation. "This law of the inverse square," says a writer in the last number of the *Quarterly Review* (London), "is but the mathematical expression of a property which has been imposed on matter from the creation. It is no inherent quality, so far as we know. It is quite conceivable that the central law might have been different from what it is. There is no reason why the mathematical law should be what it is, except the will of the Being who imposed the law. Any other proportion would equally well be expressed mathematically and its results calculated. As an instance of what would occur if any other proportion than the inverse square were substituted as the attractive force of gravity, suppose, at distances 1, 2, 3, the attractive force had varied as 1, 2, 3, instead of the squares of those numbers. Under such a law any number of planets might revolve in the most regular and orderly manner. But under this law the weight of bodies at the earth's surface would cease to exist; nothing would fall or weigh downward. The greater action of the distant sun and planets would exactly neutralize the attractive force of the earth. A ball thrown from the hand, however gently, would immediately become a satellite of the earth, and would for the future accompany its course, revolving about it for the space of one year. All terrestrial things would float about with no principle of coherence or stability—they would obey the general law of the system, but would acknowledge no particular relation to the earth. It is obvious that such a change would be subversive of the entire structure and economy of the world."

Much the same might be said of the chemical, the electric, and magnetic properties of matter. If they were among the original powers, there is proof of design in their adaptation to one another and to the matter of the universe. If they were not, then we have traces of a new power being introduced, and for this we must look for a cause. We are not able to say how many the properties possessed by the original matter; whether they were few or many. But in either case there is evidence of contrivance in their harmonious action and results. We see that there is an end proposed in the music that comes from a violin, and this whether it is brought forth from one string, as was done by Paganini, or from four strings, as is done by the ordinary performer. So in the orderly and beneficent action of Nature there is proof of adaptation, whether we suppose the original properties to be few or to be numerous.

Though preservation is in a sense a continued creation, yet preservation differs from creation. In looking back on the history of the world, it is often difficult to tell as to a certain work to which of these two kinds of divine acts it belongs. We may not be sure, for example, as to a new form of plant or animal, whether it is a creation or simply a development according to law; and I am not sure that religion gains by our taking one side or another. We cannot, we have seen, determine for certain what were the powers of Nature that were working from the very beginning. But it is clear and sure that powers have appeared in Nature from time to time which did not operate at first nor for long ages; nay, if geology speaks truly, nor for millions of years. There may be two suppositions in regard to these powers. The one is, that they were all along in the original matter; that the star-dust had in it potentially not only gravitation and chemical affinity, but life, sensation, consciousness, intelligence, moral discernment, love. It is hard to believe that there was all this in that dull, heated, nebulous matter from which our world sprang. It is acknowledged that this mass must have existed for a long time —for hundreds of thousands, probably for millions of years—before life, and for a far longer time before intelligence, appeared. Whence did these new powers come? If they were in the original matter, how did it come that they were so long dormant, how that they at last appeared, it might be shown, at the appropriate time when surroundings were prepared for them? Science can say nothing on this subject, and may never be able to say anything. It is passing altogether beyond its province, passing from inductive proof into speculation, when it pretends to know anything one way or other. Philosophy feels itself staggered when it would solve the problem. It does say, indeed, that this new operation must have had a cause. It is one of the certain laws of intelligence, one of the universal laws of experience, that everything that begins to be must have a cause. This law of causation takes several forms; but every form will insist that these new

operations must have come from a causal power. "Ex nihilo nihil fit" is a maxim going back farther than I am able to tell. The form given it by the great atheistic poet Lucretius is:

". . . Nihil posse creari.
De nihilo, neque quod, genitu est ad nihil revocari."

Persius puts it:

". . . Gigni
De nihilo nihil, in nihilum nil posse reverti."

Take either of these forms, or any form, and it insists that we seek a cause of the new kind of operation. It cannot discover that there was anything in that heated, vaporous matter to produce life and sensation, when they appeared millions of years after the world had begun to be formed. I will not decide dogmatically whether the causal action was natural or supernatural. Perhaps we are here come to a place where the distinction between natural and supernatural is lost in the dim distance. The cause may have acted according to a law. But in that case I must hold it to be a divine law. Even in the supposition that it has been brought about by a conjuncture of circumstances, unknown for the indefinite period before, it must have been a providential juncture foreseen, nay, ordained by God.

Life appears ten thousand ages or more after the earth began to form. Whence this life? Prof. Huxley seems to find it in some protoplasm or gelatinous substance. Was this one of the original elements of the nebulous matter? If so, how did it come through that terribly heated temperature? If it did not exist till after the temperature had cooled, how did it come in? Prof. Huxley has been the most determined opponent in our day of the spontaneous generation of life, and is thereby left without a means of generating the life of plants and animals. Darwin feels himself obliged, in order to account for the phenomenon, to suppose that there were four or five germs created by God. Tyndall thinks that Darwin has at this point fallen into a weakness. But, meanwhile, Tyndall has no means whatever of accounting for the appearance of life. Mr. Darwin further calls in a *pangenesis*—which is just another name for the *vital force* of the older naturalists—in order to account for the generation of new animals. But he does not tell us, and evidently cannot tell us, whence this pangenesis, which cannot come from development, of which it is the source, and not the product. Herbert Spencer prefers to bring in *physiological units*.

Whence comes sensation? There was a moment when sensation pleasurable or painful was felt for the first time in the universe. Was this at the beginning? If so, one wonders how the sentient substance came through the heat, where, so far as we can judge, it must have been suffering intolerable anguish without the power of relieving itself by self-destruction.

Had this protoplasm self-consciousness? I rather think that neither Prof. Huxley nor Prof. Tyndall would say that it had. Animals from the very first have sensations, and also, at least the higher ones, ideas and very curious instincts, by which they make provision for coming evils of which they can have no conception. Finally, in the last of the unnumbered ages we have man with his intelligence, his conscience and free-will, all attested by consciousness. Will evolutionists pretend that on any rational or inductive principle they can tell how these new powers came into being and into action? When the book of Genesis tells us how these agencies did come in, and in particular how man appeared, science has and can have no facts to lead us to discredit it.

3. *There is Final Cause in Nature.*—Laplace, a great mathematician but not a great philosopher, imagined that, when we have discovered an efficient, it is not necessary to seek for a final cause. Aristotle, with a much more enlarged conception of the nature of the universe, maintained that we are to seek for both these causes—and for two others besides, the material and the formal. The fact is, that final causes presuppose efficient causes; and the efficient causes effect, by their coöperation, the final cause. We argue final cause, that is design, from the collocation of efficient causes to promote an evident end, say the ear to hear and the eye to see. The doctrine of development does not undermine or in any way interfere with the argument from design. This was asserted by Hugh Miller when the "Vestiges of Creation" was published, and has been gracefully illustrated and defended by Prof. Asa Gray in his pleasant book, "Darwiniana." When we argue that a watch has had a maker, we do not suppose it necessary that the watch should have been made by an immediate fiat of the mechanic. We so infer, because we discover agents combined to produce a particular effect, and the combination of these may have taken days or weeks of patient labor. So, the fact that the present adaptations and forms of the plant and animal may have been produced by a great number of antecedents, acting through ages, does not show that there is no design, but rather proves that there has been a bountiful end contemplated all along, and effected by a long process. Prof. Huxley, in the opening of his last lecture, has expressed his admiration—an admiration with which I thoroughly sympathize—of the structure of the horse: "The horse is in many ways a most remarkable animal, inasmuch as it presents us with an example of one of the most perfect pieces of machinery in the animal kingdom. In fact, among mammalia it cannot be said that there is any locomotive so perfectly adapted to its purpose, doing so much work with so small a quantity of fuel, as this animal, the horse." He speaks of the beauty of the animal arising "from the perfect balance of his parts and the rhythm and perfection of their action. Its locomotive apparatus is, as you are

aware, resident in its slender fore and hind legs, which are flexible and elastic levers, capable of being moved by very heavy muscles. And in order to supply the engines that work these levers—the muscles—with the force they expend, the horse is provided with a very perfect feeding apparatus and very perfect digestive apparatus." In all these things being *provided*—the phrase used by Huxley, though he has no right to use it—there is evidence of purpose, and this is not diminished, but rather increased, by the fact that the animal has been thus perfected by a long descent from an ancient progenitor. The argument of Paley and of the Bridgewater Treatises, derived from the bones and muscles of animals, and from the adjustments in every part of Nature, is as valid and convincing as ever. I believe Prof. Huxley admits this. I discover adaptation and contrivance, not only in the products but in the very process of development. Viewed in this light, development may, in the hands of a new Paley, furnish further and very striking cases of design. For, in order to the success of the process, there is often need of coördinated structure, that is, of a structure in which a number of parts are adapted to each other. My friend Mr. Joseph J. Murphy has supplied us with an instance in the case of the two nervous connections of the iris of the eye. "One of its nerves has its root in the brain, and contracts the pupil under the stimulus of light; the other has its root in the sympathetic ganglia, and opens the pupil again when the intensity of light is diminished. It is obviously impossible that the efficiency of either of these two nerves could be increased separately; they will not be improved at all unless they are improved together; and this, on Darwin's principles, can only be done by means of accidental favorable circumstances occurring in both at once. But such coincidences are so improbable that they may be left out of account as if they were impossible." I do not agree with Mr. Murphy in thinking that such an instance tells against Darwin; but I think the coincidence shows a preordained arrangement, and such coincidences are found in nearly every case of development, thus showing the need of coöperation and contrivance in the very developing process. It is to be observed that evolution, vegetable and animal, and natural selection, are not simple properties of matter like gravitation and chemical affinity. They imply the concurrence of an immense number of agents, mechanical, chemical, electric, galvanic; and Darwin adds pangenesis, and Spencer physiological units. In the concurrence and coöperation of all these to develop the plant and animal, I see proof of purpose; and in the culmination of the whole in the perfect forms of the higher animated beings, I discover a guiding intelligence which designed the end from the beginning.

4. *There are Typical Forms in Nature.*—It is now twenty years since, in conjunction with Dr. Dickie, I wrote "Typical Forms and Special Ends in Creation," in which I showed that there was not

only final cause, but a designed general order in Nature. When I composed that work I was filled with admiration of the discoveries made by Goethe and Oken, by Owen and Agassiz, as to the beautiful "forms" in Nature. Some may think that the more recent doctrine of development has made that treatise obsolete. I admit that these late discoveries might require me in some places to change my mode of expression; and the time has scarcely arrived for rewriting that book, and will not arrive till Darwin's doctrine and Owen's doctrine are more thoroughly adjusted. But, meanwhile, the argument is as valid as it ever was, and proves that there is a designed order and beauty in Nature, the design being not less evident because the order and beauty have been brought about by a process of development. This has been shown fully and satisfactorily by St. George Mivart in a recent article in the *Contemporary Review*, entitled "Likenesses or Philosophical Anatomy," in which he writes in the same way as I did of homologies, and shows that many of these cannot be explained by development or by a descent from a common parentage. He shows that "there are likenesses between different animals and different parts of the same animal which a theory of common descent cannot explain." He specifies instances of lateral, vertical, and serial homology, such as the vertebræ which make up the backbone, all similar, and the likeness between "the thigh, leg, and foot, of the lower limb, evidently more or less repeating the upper arm, arm, and hand, of the upper limb." I am inclined to argue that there is evidence of design in homologies which may have been produced by descent, as when we see the pectoral limb of the horse, the whale, and the bird—whether fore-leg, paddle, or wing—formed on one type, though turned to very different uses. All that Owen and Agassiz have said about the anticipations and the prophecies in Nature may be acknowledged as true, even by those who hold that they have been produced by development. I do believe that these old horse-like forms were preparations for the horse now living. The efficient cause may have been development, but the formal cause (to use Aristotle's phrase) is the perfected animal. We cannot allow this evolution doctrine to shear Nature of its grandeurs, nor, we may add, morality of its binding obligations or the universe of its God. Mr. Mivart concludes: "The teaching of what we believe to be true philosophy is that the types shadowed forth to our intellects by material existences are copies of divine originals, and correspond to prototypal ideas in God."

I close this article with remarking that these views bring Nature and revelation, geology and genesis, into harmony.

The Book of God begins at the beginning—with Genesis, the generation of all things. Science does not seem to tell us of a beginning. The Bible opens, "In the beginning God created the heavens and the earth." It tells us that there were an order and a progression in the generation of our world. First, there is an original creation.

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Then the earth is "without form," without the order which it subsequently assumed; and "void," that is, without inhabitant. Light appears, and an alternation of day and night. There is a separation of the lighter matter from the grosser, of the aërial expanse from the earth proper. Then a separation of the sea from the land. Life now appears, and we have grass and trees. As yet the sun and moon have not appeared as formed bodies. Now, on the fourth day, they might be seen, and become dividers of times and regulators of seasons. All this is in accordance with science, which says that the earth is older than the sun; that the earth was formed out of an original matter and that there must have been light before the sun was condensed into its present form. Animals now appear first in the waters, swarming creatures and fishes, then reptiles and birds. On the sixth day we have animals—herbivorous and carnivorous. Finally, we have man. All this is very much the same order as is disclosed in geology, and was written there in that volume three thousand years before geology made its discoveries.

But we are most concerned with what, after all, is the most important to us, and that is the creation of man. There is a twofold record, the parts not contradictory but supplementary the one of the other. Chapter ii. 7: "And the Lord God formed man of the dust of the ground, and breathed into his nostrils the breath of life, and he became a living soul." This is expanded in a passage full of meaning: Psalm cxxxix. 15, "My substance was not hid from thee when I was made in secret and curiously wrought in the lowest parts of the earth," seeming to indicate a process and a preparation; "thine eyes did see my substance being yet imperfect, and in thy book all my members were written while yet there was none of them." Such is the one side, the animal side. But then we have the other side, chapter i. 26: "And God said, Let us make man in our image, after our image, after our likeness. So God created man in his own image, in the image of God created he them." All this corresponds to our experience. We feel that we have an animal part cleaving to the dust, and allying us to the brutes. But we feel also that we have a divine nature, a power of distinguishing between good and evil, a longing for something higher, a seeking after God. The Bible tells, thirdly, that this image of God has been defaced. These truths have been combined in an eloquent passage by the profound Pascal: "The greatness and the misery of man being alike conspicuous, religion, in order to be true, must necessarily teach us that he has in himself some noble principles of greatness, and at the same time some profound source of misery. . . . The philosophers never furnish men with sentiments suitable to these two states. They inculcated a notion either of absolute grandeur or of hopeless degradation, neither of which is the true condition of man. . . . So manifest is it that we were once in a state of perfection from which we are now unhappily fallen. It is astonishing

that the mystery which is farthest removed from our knowledge—I mean the transmission of original sin—should be that without which we can have no true knowledge of ourselves. It is in this abyss that the clew to our condition takes its turnings and windings, insomuch that man is more incomprehensible without this mystery than this mystery is incomprehensible to man."

SKETCH OF DR. ARNOTT.

AMONG the agencies for the diffusion of the knowledge of physics and the taste for its study in the past generation, few were more effective and successful than "The Elements of Physics," a treatise for schools, by the author whose portrait will be found in the present number of the MONTHLY. It was a work in many respects of peculiar and remarkable excellence, from the felicitous treatment of the subject, the fullness and aptness of illustration, the pleasant and attractive style, and what may be called the practicalness of the book, or the prominence it gave to the exposition of familiar phenomena. Many students of both sexes in our higher schools received a bent in the direction of scientific study from the use of this text-book, which lasted through life; and, as a new edition of the volume is about to appear, brought up to the time by judicious and able editors, there are many who would like to know something about the personal character and life of the author.

NEIL ARNOTT was born on the 15th of May, 1788, at Arbroath, in Scotland. On his father's side he was descended from a Lowland family, and his mother was the daughter of a Highland clan. His youth was passed at Dysart, near Montrose. At the age of ten he became a pupil in the Aberdeen Grammar-School, where he remained the next three years.

In consequence of having been successful at the Bursary competition at Marischal College, in 1801, he became a student there, and completed the regular course, obtaining the degree of M. A. in his seventeenth year. It was during his third year in college, under the admirable instruction of Prof. Copland, that his mind was directed to natural philosophy, which henceforth became his favorite study. He chose medicine as his profession, and went through the medical course at Aberdeen. For the purpose of completing his studies, he went to London in 1806, and became a pupil in St. George's Hospital, under Sir Everard Home. Through the influence of the latter, he was appointed surgeon in the East India Company, where he gained valuable experience for his after-work. Having settled in London in 1811, he not only obtained large success as a medical practitioner, but at the same time was collecting materials for his future work on "Physics." In 1815 he was appointed physician to the French embassy, and after-

ward to the Spanish embassy. In 1836 he became a member of the Senate in the newly-founded University of London in 1837, one of the physicians extraordinary to the queen, and in 1838 a member of the Royal Society, and subsequently of the Geological Society.

Dr. Arnott gave two courses of lectures at different times on the relation of natural philosophy to medicine. These were afterward embodied in his "Physics." In 1837 appeared his well-known "Essay on Warming and Ventilation," and, by the practical application of the theories contained in it, there resulted the stoves and ventilators which bear his name. For these and other inventions, including the water-bed, he obtained from the Royal Society the Rumford medal. On account of the assistance which he rendered to the practice of medicine, and to the general public health, he received, at the Paris Exposition in 1855, a gold medal, added to which by the emperor was the cross of the Legion of Honor. During his connection with the General Board of Health, he devoted much of his time to the subjects relating either directly or indirectly to hygiene. Not only here, but during his whole life, he had exercised and used his observing powers, so that each new experience added to his valuable stock of facts, which bore especially upon natural philosophy.

Many traits of his character made him a social favorite, and his interest in society at large has justly caused him to be ranked among the chief promoters of human welfare. All his actions were characterized in a remarkable degree by unselfishness. He used none of his inventions in his own interest, and refused to have them patented, in order that their usefulness might be more wide-spread. As Prof. Bain, one of the editors of his "Elements," remarks: "Throughout his life, and by his various inventions and publications, Dr. Neil Arnott manifested a purely philanthropic desire to extend to others the benefits of that knowledge which, from his boyhood upward, he had acquired by long and patient observation. His earnest wish was to make the path of learning easy to all. We have now before us a copy of 'The Elements of Physics' as it first appeared in 1827. Within five years of its publication, five large editions of the work were called for, and, although not then complete, it was translated into several foreign languages. It is not too much to say of this and his other works that the learned and the unlearned, the student and the philosopher, have equally benefited by his labors." In addition to his general benevolence referred to above, he strove to promote the advancement of physical science by endowing scholarships in the universities and public schools. In 1869 he gave $10,000 to the University of London, and $5,000 each to the universities of Aberdeen, Edinburgh, Glasgow, and St. Andrews. Not having accomplished a design expressed by him of leaving $5,000 to each of the four Scotch universities, his widow has carried out his plans since his death. He died on the 2d of March, 1874.

CORRESPONDENCE.

GETTING RIGHT ON THE RECORD.

To the Editor of the Popular Science Monthly.

DEAR SIR: It has always been a matter of surprise to me that some of my contributions to botanical science should be regarded as attacks on the doctrines of Darwin, or as opposed to theories of evolution. At the conclusion of the reading of my papers it is often a subject of argument on which side I stand. So great is this nervousness, that at Buffalo, because I showed that the ova-pollen of a yucca-flower was as potent as any that could be brought from another flower by an insect, I had to endure a sharp lecture from Prof. Riley, and even Prof. Morse could only help me with the audience by remarking, "We all know that Mr. Meehan is a Darwinian and an evolutionist, but must say that he has an odd way of putting it." That my good friend does not regard me as much of either is, however, clear, from his making no reference to any of my labors in his "History of Evolution."

For my own part I have not cared to be classed nominally with any party in science, but to let the facts I record speak for themselves. My ambition has been to be considered a worker in the field of original observation and research, and, if I know myself, am indifferent whether the facts help my own or any other person's beliefs or theories. Still, even an observer must have some idea of the bearing of what he sees on evolution and Darwinism, if he think at all about these things. I have thought it would do no harm if for once I entered the speculative field and put my own interpretation on the facts as I have recorded them.

Instead of opposing evolution, I think my Hartford paper was a contribution to its cause. I not only showed that in plants there is an evolution of form by slow and gradual modifications through long series of years, but also that evolution is often by sudden leaps, and that these sudden entrances were just as permanent, when the agents in natural selection favored, as any new form gradually evolved could be. I also showed the probability of whole districts changing by the operation of some inherent law, which would make the doctrine of evolution possible to those who can hardly believe every individual in a species came from one primordial form, one exact mathematical centre. Of course, so wide a generalization could not, ought not, to rest on so small a number of facts; but surely any one can see that if there be, and have been through all ages, change by sudden introductions as well as by slow modifications, there is no use in hunting in all cases for "missing links" that never existed; and I have found a plank on which Agassiz and his friends might have stood with Darwin; and I could render no better service to evolutionary views.

So in reference to cross-fertilization by insect agency, I regard myself as saving Darwinians from themselves. By cutting out a rotten branch the tree is made healthier, and the possibility of a fall prevented to those who might crawl out on it. To my mind, there is nothing more opposed to the idea of natural selection than the modern doctrines in relation to insects and fertilization. Supposing that, in accordance with the inherent tendency to variation, a new form—a slight change—occurs that renders the plant better fitted to engage in the "struggle for life" than its parent, and that it is unable to make use of its own pollen, but must have pollen by insect agency from some other flower. The advantage it has gained is at once lost, as the crossed progeny of course is brought back to near its grandparent, and these again crossed with the foreign pollen are again reduced, till in the course of a few generations the variety is near enough to be the same. The effect of continual adding of water to milk is well known. In the supposed case of our plant, it becomes "watered stock" with a vengeance. If the new form could have the power of reproducing itself exactly, and thus continue to fix a habit, as we can un-

derstand it might do in using its own pollen, we can see how "natural selection" could use "variation" to advantage. The insect only interferes with the law.

There are some few plants which never seem to fertilize except by insect or other aid. In a large number of these cases their own pollen is just as good as foreign pollen. In a few instances foreign pollen alone seems to be potent. Why must we believe, in this latter case, that it is because their own pollen is designed to be inferior, in order that foreign pollen may be brought to it? There may be many other reasons. At any rate, the creed presented to us is inconsistent with a full idea of natural selection. The survival of the fittest will be most assured by an abundance of resources. The little chickweed which flowers and seeds with the thermometer at 35°, and the common erophila at 40°, are much "fitter" to fight their way through the world in the wonderful way they do than if they waited for the spring insect to bring them foreign pollen. We can readily understand that if a flower is diseased, the pollen of that flower acting on itself would produce diseased offspring. Foreign pollen would bring back the health. With the millions of healthy flowers reproducing, the one flower diseased seems but trifling; but even so the insects can carry bad pollen to good flowers, as well as bring good pollen to diseased ones. Only that I have heard the argument from the highest in scientific standing, it would seem too puerile to mention here.

Without going further into detail, I may say that, as a matter of opinion, the observations I have placed on record aid evolutionary views in some of their weakest points, while I am really saving the doctrines of the survival of the fittest and of natural selection from injuries dealt out to them in the house of their friends.

THOMAS MEEHAN.

GERMANTOWN, PA., *September* 28, 1876.

EDITOR'S TABLE.

PROFESSOR HUXLEY'S LECTURES.

PROF. HUXLEY arrived in this country tired out from prolonged overwork, and greatly needing rest. He did not wish to speak in public, but could not escape it. He went to Nashville to visit a sister whom he had not seen in thirty years, and, being strongly urged to make a public address there, he reluctantly consented, and spoke to a large concourse on an excessively hot day. The effort prostrated him, and his voice was so strained that he did not recover his usual vocal power while he remained with us. He had not expected to make a formal public discourse at Baltimore, and therefore had to prepare one while here. His vacation thus turned out to be anything but a season of repose and recuperation, and he gave his lectures in New York under the triple disadvantage of not being up to his usual vigor, of a serious impairment of voice, and of having to prepare them as he went along—for the plan of the discussion was new, and American materials had to be worked up for its purpose. These difficulties became serious in dealing with the crowded audiences which attended his lectures, many of whom heard him but imperfectly.

His lectures were, however, well received by those who heard them, and quite as well received by the press as we had any reason to expect. That objections of all sorts should be raised was inevitable; for the doctrine of Evolution, which he advocated, is too recent, too comprehensive, too scientific, and encounters too many prejudices, to be generally or readily accepted merely because it is proved. Only a very small portion of human opinion is the product of reason. Some thought his treatment of the subject too elementary, and some thought it too restricted and inadequate, but nobody denied that it was clear, forcible, and logical. We must add that, in most cases, the pulpit has

treated Prof. Huxley with courtesy, though it could be wished that the clergy would inform themselves a little more thoroughly upon the subject before answering him with such perfunctory promptness.

In one thing both the professors, auditors, and the public generally, have been seriously disappointed. They have been led to regard Huxley as a man of pugnacious temper, a kind of controversial bully, who is only happy when in a fight. And so they expected to see some brilliant aggressive work, and that he would "polish off" his adversaries in the most approved and exciting style of polemical pugilism. But Prof. Huxley indulged in nothing of the kind, and so it was murmured round that the lectures were disappointing, and not at all up to what was expected from him. That is, the man himself, when observed, and heard, and known, contradicted the preconceived theory of the man. And here is the proper place to say that this current theory of Prof. Huxley's character is quite erroneous. He has been a good deal in controversy, no doubt, and has often hit hard; but it is a total mistake to suppose that he has ever sought or provoked strife because of combative propensities. His dominant tastes and inclinations are all, on the contrary, for quiet scientific inquiry. Controversy has, however, been thrust upon him. Standing prominently as the exponent of a doctrine that has been regarded with horror for the last twenty years by all classes, high as well as low, he has been misrepresented, and badgered, and vilified, with a recklessness that would have aroused vigorous resistance and sharp counterstrokes in any man of spirit.

In his opening lecture Prof. Huxley showed first that Nature, or the universe, has not always been what it is now. To minds that seek for causes it therefore presents the problem, How did it come to be what it is now? The theoretical solution of this problem that has prevailed in the past and is still widely accepted is, that it was called into existence a few thousand years ago in much the condition that we now know it. This is the Mosaic theory, in its old and popular interpretation. But as the Mosaic records have been reinterpreted in recent times, and as the question whether or not the doctrine is taught there is hotly disputed among those who defer to Mosaic authority, Prof. Huxley did not assume to settle the question, and wisely let the Mosaic account alone. Some newspapers were indignant at this, and charged him with cowardice and evasion for not pitching into Moses. But that was not his business, and if he had done so he would have been open to the charge of going out of his way to drag in a foreign question, and make an assault upon the Christian religion—there is no pleasing everybody. But, while keeping clear of the Scriptures, he still had to deal with the doctrine which has been universally believed for centuries to be grounded in Scripture authority, and so he took it as vividly and concretely described by a classic Christian poet more than two centuries ago. He called it the "Miltonic hypothesis," and read a graphic passage from "Paradise Lost" describing the way the animal world came into existence. Herbert Spencer has been soundly belabored by various critics for calling this view the "carpenter theory" of creation, but the great Christian poet certainly lends his authority to this interpretation of the case. He describes the creative work with great literalness as a mechanical operation, in the following lines:

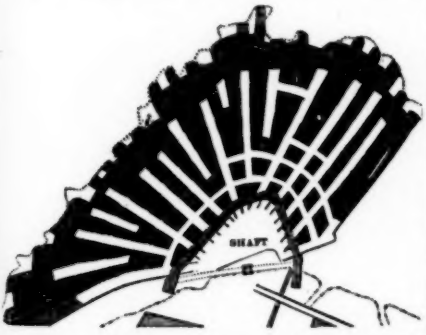
"....In his hand
He took the golden compasses, prepared
In God's eternal store, to circumscribe
This universe, and all created things:
One foot he centred, and the other turned
Round through the vast profundity obscure;
And said, 'Thus far extend, thus far thy bounds,
This be thy just circumference O world.'"

But further comment is unnecessary, as the reader will find the full lecture in our pages.

THE HELL-GATE EXPLOSION.

THE series of operations which resulted in the blowing up of the great rocky reef at Hallett's Point on Sunday, September 24th, must be regarded as the most brilliant piece of scientific engineering that has yet been accomplished. General Newton formed his plans, and entered upon the work in July, 1869. For over seven years he has been preparing for a grand experiment to occupy but a few seconds, and so accurately did he calculate, and so complete was his command of the irresistible forces to be called into action, that the experiment proved completely successful, and affords an impressive illustration of the prophetic power that is conferred by a knowledge of the elements and forces of Nature. It was the physicists and chemists who long ago worked quietly and obscurely in their laboratories, with little reference to practical ends, and animated only by the desire to acquaint themselves with the laws of the natural world, that paved the way for the great engineer to do this important service for the interests of New York and the commerce of the world.

The reef at Hallett's Point, which has formed such a dangerous obstruction in the Hell-Gate channel as greatly to hinder navigation through Long Island Sound, was of an irregular crescent shape (as shown in the figure), some



700 feet long, and extending out 300 feet into the channel, with an area of about three acres. The rock is a tough, hornblende gneiss, with veins of pure quartz, and lies in strata of various degrees of inclination. The plan of operations was to build a coffer-dam on the rock near the shore to bar out the water, to sink a shaft to the requisite depth, to honey-comb the whole rocky mass by excavation, and then to blow up the shell by charges of dynamite in the roof and supporting columns, to be fired by the agency of galvanic batteries. The shaft was sunk to a depth of 33 feet below the line of low water, and ten tunnels were then opened to distances varying from 31 to 126 feet. The cubic contents of the rocky mass, above the depth of 26 feet, at mean low water, amounted to 51,000 yards. The tunnels radiating from the shaft varied from 7 to 22 feet in height, and from 9 to 12 feet in width, and, as they advanced, the height rapidly decreased, owing to the downward slope of the surface of the reef. As the main tunnels diverged from each other, subsidiary tunnels were introduced, and a system of transverse galleries was excavated (as shown in the figure), and which left 172 supporting pillars of variable dimensions. The total length of tunnels was 4,857 feet, and the length of galleries 2,568 feet, making the entire length of passage excavated 7,425 feet. The excavations being completed, so that the roof of rock above was reduced to a thickness of from 8 to 16 feet, the preparation for the explosion began by drilling the rock for the charges. The whole number of blast-holes drilled into the roof and piers was 4,427, varying from 7 to 10 feet in depth, and from 2 to 3 inches in diameter. Each one of these holes was charged with three kinds of explosives, all compounds of nitro-glycerine, viz., dynamite, rendrock, and vulcan-powder, in separate cartridges or canisters. Fifty thousand pounds of these explosives were buried in the apertures. Ninety-six galvanic batteries, of ten cells each, were employed to ignite the charges. The firing-point was 650

yards from the shaft, and the amount of leading and connecting wire used to bring all the charges into relation with the batteries was 220,000 feet. The charges in the different holes of the same pier were connected so as to explode simultaneously, but a fuse composed of a quick explosive was used to connect the system of charges in each pier with those of the neighboring piers. In this way the electric spark, taking effect in a few centres, the ignition was propagated through the whole system, as the explosion of the connecting fuse would advance more rapidly than the destruction of the rock. The several thousand charges in the mine were connected in 23 groups, each with 160 fuses, and these were acted upon simultaneously by 23 groups of batteries. These were ingeniously connected in a mechanical arrangement so simple and perfect that a child could operate it, and the whole stupendous force that slumbered in the charges was actually released by the touch of a little daughter of General Newton, two years and a half old. The explosion was accompanied by no very stunning effects to eye or ear, and the demonstration was so moderate as to produce great disappointment in the multitudes who assembled to witness it. There was a succession of shocks, lasting a few seconds, with no great noise, a mass of water and *débris* of the coffer-dam thrown into the air, and the great reef was shattered and demolished. Long experience in blasting, and the close adaptation of explosive material to the work done, had enabled General Newton to graduate the amount of power to be developed to the total result; and so accurate was this adjustment that the explosives spent themselves in breaking up the reef, and no power was left to topple down the houses in the vicinity. Examinations thus far show that the great blast was most effectual, although considerable time and much labor will probably be required to clear away the broken masses of rock, and gain the full benefits aimed at by the enterprise.

DR. DRAPER'S BOOK AT ROME.

THAT extensive division of the Christian Church which has its headquarters at Rome has claimed and exercised for more than 300 years the right of deciding what books its members shall be allowed to read. This power resides in a body of cardinals, designated by the Pope, who issue an "Index" of books containing a twofold catalogue, one of which is of works absolutely prohibited, and the other of works that are prohibited only until they are expurgated, or so corrected by their authors as to be acceptable to the Church authorities. The first papal "Index" was published in 1549, by Pope Paul IV. It was made a part of the work of the Inquisition, and this body had charge of it until 1586, when a special commission—"The Congregation of the Index"—was created, and has been maintained to the present time. Among the early works prohibited by this conclave were those of Galileo, Copernicus, and Kepler; and, among those forbidden in more modern times, were Locke's "Essay on the Human Understanding," and Mill's "Political Economy." Dr. Draper's "History of the Conflict between Religion and Science" has now the honor of being added to the list of celebrated books which Catholics cannot read without rebelling against ecclesiastical authority.

This institution of the Catholic Church is itself the most conspicuous example we have of that great "conflict" which Dr. Draper has so vividly delineated in his little volume. Its rise was coincident with the general awakening of thought in modern Europe, which was manifested on the one hand in the Protestant Reformation, and, on the other, in that independent study of Nature by which the sciences have been

created. The Church took issue with this spirit of free thought, which it sought to repress by violence wherever and as long as it had the power, and which it still seeks to extinguish by the force of its claim to represent divine authority. It is still as vicegerent of God upon earth that the Pope interposes to stop the circulation of scientific books, and continues his warfare with the tendency to independent inquiry.

We cannot but remark how greatly the papal government mistakes the times, and how utterly it fails to realize the change that has taken place since the sixteenth century. The time has come when books are not to be *forbidden* but *answered*, and the policy of interdiction by the Vatican authorities is so futile that it becomes nothing short of a blunder. Dr. Draper's volume has been put under ban because it is pervading all Europe—two editions having been called for even in ultra-Catholic Spain. Publicly thus to mark a book for religious outlawry is simply to give to it a prodigious advertisement. Where before it had one reader it will now have ten. Men will get it, determined to find out for themselves in what its offense consists; and women will do as Eve did—taste simply because it is a forbidden thing. The only way to overcome the objectionable tendencies of any work is to point them out; and the only way to deal with its arguments is to refute them. To suppress such books in our time is out of the question; and if, in this special instance, there are among the highly-educated ecclesiastics in Rome none who can do this, the inference is that the book is unanswerable. We have, certainly, no complaint to make of the course adopted by the theological authorities at Rome, and must, at any rate, give them credit for consistency; but they forget that the world has changed a good deal since the Inquisition was established.

AS REGARDS BISHOP COXE.

It is a great mistake to suppose that bigotry and intolerance are altogether confined to the Vatican; we have excellent illustrations of this temper much nearer home. While the Pope at Rome is commanding the faithful not to admit Dr. Draper's book into their libraries, Bishop Coxe, the little pontiff of Western New York, is warning the good Christians of Buffalo not to let Prof. Huxley come into their houses; while both potentates put their intolerant action on the same ground of divine authorization. One would think that in the nineteenth century, in an enlightened American city, in the year of the nation's centennial, in the midst of a presidential campaign, and at a large convocation of the scientists of this and foreign countries, Buffalo Christians might have been left to their own good sense and good taste to entertain whom they pleased. Moreover, Prof. Huxley was the guest of the American Scientific Association, which was itself the guest of the city, and this should have been sufficient to protect him from insult from such a quarter. It is well that the bishop's type of Christianity does not prevail in Buffalo, as, otherwise, the obnoxious foreigner might have been left in the streets to starve.

Some of the Buffalo papers, holding the bishop's utterance in regard to Huxley to be nothing less than a public affront and a disgrace to the town, made it rather warm for him, and so he has followed up the original mandate by a defense of it in subsequent letters to his organ, "The Orbit." The faithful were admonished to withhold their hospitalities from Prof. Huxley, because he is an atheist. The bishop charges him with "scientific atheism"—whatever that may mean—and refers to his admonition to his flock for "importing atheism into their families under color of science." He also accuses Prof.

Huxley of being a "propagator of atheism." Now, though these charges are launched from the Episcopal throne of Western New York, they are nevertheless not true. Bishop Coxe says, "I bear a divine commission." Then he has a divine commission to bear false witness. His accusation is simply a baseless calumny, and in none of his communications does he offer a shadow of proof to substantiate the charge. Prof. Huxley has never avowed himself an atheist, and has never advocated the doctrine, but on the contrary he has distinctly condemned it and declared it to be an absurd doctrine. Bishop Coxe says he is "a propagator of atheism," but where is the proof? There are such people as avowed atheists, and there is a party of them in England that labors to propagate the belief. Bradlaugh is one of their chiefs, who boasted that he is the only man who ever ran for Parliament on the issue of being an atheist. Prof. Huxley has never had anything to do with this party, and is no more in sympathy with it than is Bishop Coxe. If Prof. Huxley has propagated atheism, he must have done it some time, somewhere, and somehow, and there must be evidence of it. Has the bishop any better source of information than other people? If not, then he has lent himself to a false accusation. He quotes Scripture copiously in defense of his course, and cites from St. John the following passage: "Many deceivers are entering into the world. Look to yourselves . . . receive them not into your house." But, who are the deceivers, if not those who mislead people by untruthful statements? The utmost defense that Bishop Coxe can make is, that he has heard Prof. Huxley called an atheist, or that he infers from his books that he holds atheistic opinions; but is a man to be stripped of his character, and loaded with opprobrious epithets, and are all good Christians to be invited to slam their doors in his face, because of mere idle rumors and inferential constructions of his writings, both of which are contradicted by his explicit averments? The Bishop of Western New York should migrate to Rome, where he properly belongs, at the earliest opportunity.

LITERARY NOTICES.

TALKS ABOUT LABOR, AND CONCERNING THE EVOLUTION OF JUSTICE BETWEEN THE LABORERS AND THE CAPITALISTS. By J. N. LARNED. Pp. 150. Price, $1.50. D. Appleton & Co., 1876.

THIS book is the result of an able effort to analyze the present relations of capital and labor, and to point out the directions whence future improvement in those relations must come. It has not the pretensions of an exhaustive treatise; nevertheless it is a study of the whole subject, and reaches to large conclusions. It is conceded on all sides that, as between laborers and capitalists, grave problems have to be settled before their relations can be adjusted to the higher notions of justice now pressing on the minds of men. The men with capital, and those without it, but with capabilities for work, must be in constant coöperation, the terms of which are determined by complex facts. The fairness or unfairness of these terms bears closely on our social life, and is an index to the quality of our civilization. We cannot turn away from them, relying entirely for their amelioration on the operation of forces beyond human control. The social philosophy imbued with the spirit of science tells us that the institutions of social life develop only in obedience to irresistible currents of educated feeling and opinion.

Without stopping to consider this thorny question, it may safely be said that prevailing mental and moral conceptions are a factor of intense importance in determining the forms of social action, and, as they pass from lower to higher states, a corresponding improvement occurs in everything upon which they act. With equal safety we may assume that this progress in our conceptions is in no way more promoted than by that activity of mind which

seeks to comprehend facts, and their relations to ethical truths.

The author of this work, profoundly impressed with the importance of the questions he discusses, has devoted himself to that consideration of his subject which includes a careful examination of existing conditions, with an inquiry into possible changes in the direction of a more complete justice between capitalists and laborers. It is a piece of good fortune that the task has been taken up in this case by a writer free from the eccentricities or narrownesses which too often beset those who discuss social questions. The literature on the subject of capital and labor is rapidly increasing, and much of it is open to a common criticism. The range of view is either too narrow, the formulæ of political economy being accepted as final and complete; or we find ourselves at the mercy of a being, utterly unscientific in his methods, who proposes to set things right by means little better than magic. Into neither mistake has Mr. Larned fallen; for, on the one hand, he has a correct appreciation of the limits to the laws which the economists have formulated, and, on the other hand, his faith rests on means of attaining ends which the most rigid scientific investigators of society must commend. As conditions change, economic science takes note and sets about the explanation of the new facts. The science is a growing one, and to take its statements to-day as an approval of existing forms of industrial life is to misconceive its nature. As Prof. Cairnes has clearly stated the point:

"It (economic science) belongs to the class of sciences whose work can never be completed, never, at least, so long as human beings continue to progress: for the most important portion of the data from which it reasons is human character and institutions, and everything consequently which affects that character or those institutions must create new problems for economic science."

The perception of this fact leads to an appreciation of our author's fundamental views. He disputes no generally-accepted economic conclusions, but gives due weight to factors, at present excluded, which, slowly gathering force, will raise new problems. He steps out into the broad field of social inquiry, and seeks to bring into clear view agencies which must in time affect human character, and modify the institutions of the present. In addition to this, the nature of those modifications is foreshadowed.

To show how clear and strong our author's position is in respect to social reforms, it is only necessary to glance for a moment at his conception of the evolution of justice in the department of human society with which he is concerned. After analyzing the function of capital, and defining it with rare precision as being "everything derived and accumulated from past labor which enables present labor to be employed in any such way that the beneficial results from it have to be waited for," two other facts of startling import are brought into juxtaposition. They are, first, *that every kind of labor which does not immediately produce for the man who performs it the immediate satisfaction of an immediate want is absolutely dependent upon capital;* and, second, *that this complex social state which we call civilization has left no labor to be done by any man that is not of that dependent kind.* Here is the dependence of labor upon capital brought home to us by a mere statement of facts. Pushing further the analysis of the conditions upon which capital and labor bargain together, and the reality of this dependence is intensified. We are invited to look at the man of capital and the man of work in the concrete, in order to realize the motives and necessities which to a large extent determine their relations to each other. The capitalist becomes an employer mainly to increase his means; the desire of gain is the most powerful motive shaping his conduct. As a bargainer, he therefore occupies a position of comparative independence. The empty-handed laborer is very differently situated. He must live; the physical wants of himself and family must be supplied; he bargains with inexorable needs at his back. Given these conditions, and human nature not apt to rise to high motives, and it is palpable that there is no limit to the possible oppression. No one claims that capital exercises to-day all the advantages of its superior position. The reasons that it does not are found in prevailing moral ideas which have

hold enough on society to restrain its conduct in some directions and elevate it in others. But these advantages are still, to an enormous extent, made use of in the division of the products of labor between the capitalists and the laborers, and, as a result, there is deep injustice in the industrial world. There has been some improvement in the past; the hopeful man sees reasons to believe in its continuance. Mr. Larned has a large faith: perceiving that this improvement has sprung from moral sources, from the slow working of juster ideas into juster conduct, he looks to the same sources for the higher progress of the future, and has been led to examine our institutions, to find out what readjustments are necessary.

Before we can follow an author, who has such a position to maintain, into the main body of his thesis, we are in self-defense bound to assure ourselves that he has an adequate conception of man's moral nature, and the working of moral forces. If he be defective here, his work must be unfruitful. Mr. Larned has spoken plainly and at length on the subject, and his views are so broad as to inspire a full confidence in his mental grasp and scientific culture. His discussion of this point is an excellent piece of exposition. The whole statement is clear and incisive, and there is about it that impressiveness which lodges a fact of grave import firmly in the mind. It is difficult to select any portion for quotation, owing to the logical connection between all its parts. We merely give here a conclusion that he arrives at, as it bears on what we have to say: "There is this order, as I believe, in the development of humanity: 1. Toward objective or sensuous intelligence; 2. Toward subjective or moral intelligence; 3. Toward the disciplining of the animal man to act in accord with his intelligence. The first of these will always be far in advance of the second; the second always in advance of the third; and yet the first and the second contribute steadily to the last, in which their whole divine purpose would seem to be consummated."

With this key given us, it is seen that the evolution of that justice which is ultimately to correct the most glaring iniquities in the relations of capitalists and laborers proceeds from the application of the accepted principles of morality to the facts attending those relations, and the deduction therefrom of higher rules of conduct. This means that the human mind has to pass through a period of moral enlightenment—a period marked by the extension of simple notions of right to the relationships in question. The average intellect does not move swiftly of its own accord to such a task, nor does it incline, by patient efforts of its own, to penetrate the darkness of a deep subject, for guidance to intelligent action. More courageous spirits must sift and analyze the material; must place by the side of the conclusions gathered together the teachings of the ethical system which humanity has worked out—and to time must be left the slow but inevitable adjustment of human conduct to the dictates of the higher intelligence thus spread abroad. The work before us is an attempt to do for its subject what has been hinted at as open to the investigator, adding to this a brief but suggestive inquiry into the changes in the machinery of industrial life which will insure to the laborers a larger share in the products of labor. In a word, it may be said to be the bringing together of the moral and economical aspects of the labor-question. A mere allusion to some of the various topics examined is all that our space leaves us.

The subjects first treated are of a general character, and are taken up to enable the author to elaborate the theoretic relation between capital and labor, deducible from primary principles. Under this head it is sought to roughly but fairly define the extent to which the advantages flowing from superior faculties may be legitimately exercised. Leading out of this theme is the allied one of the relative value of the faculties which contribute to production. If a fund is to be shared between the various contributors to it, Justice says, Let the principle of division be based on a comparison of the used energies and capabilities of the contributors. The products of labor are not divided on this principle now, and never will be until the millennium; but it is the ideal standard toward which we must tend. There is no justification in reason for the giant's share going to one class, as it actual-

ly does. Mr. Larned is particularly happy in his estimate of the faculties which are essential to the acquisition of wealth in the business-world. His analysis, too, discloses just grounds for raising the estimate usually put upon the faculties which produce the skillful mechanic, artisan, clerk, or other efficient laborer. The comparison of these two sets of faculties dispels the common notion that, as agents in the work of production, they are of widely different quality. That there is a difference is conceded; that capital is entitled to by far the largest share of remuneration is also conceded; the point is, that it exacts a larger share than any equitable principle of division gives to it.

This plea being made for labor, the author's hard work begins in finding a way to escape from the economical conclusions about the "wages-fund," in showing how that fund may be increased so that labor may receive a larger hire, and in shaping a practical plan for the accomplishment of the desired end. We commend this part of Mr. Larned's work for the strong thought and practical sagacity behind it. He is clear when he has hard knots to untie. The "wages-fund" in the hands of an economist has always appalled us. The limits to it are sketched as inexorably determined by conditions out of human reach, and the only relief open is the relative lessening of the numbers of those who share in it. Can any one wonder at men shrinking from the gloom of such a belief? Mr. Larned holds by another and more inspiring doctrine. His effort is to prove that the enormously increased productiveness of labor, through the operation of many causes which he enumerates, is more than sufficient to supply the fullest meed of legitimate human desires. If it is not so now, it is because of unjustifiable consumption and other wrongs. Let the consumption which grows out of the low desire to parade the possession of wealth be restrained by the heavy hand of public opinion, and let public-debt making be kept within certain defined bounds, so that this avenue of unproductive capital may be practically closed—let this much be done, and the result will be that those who command capital will be driven to devote more and more of it to renewed production. To such means does the author look for the increase of the fund out of which labor is paid. We have only indicated the drift of the argument.

The practical plan, advocated tentatively by the author, is a system of dividends to labor, the basis of which is given at some length. Other plans are subjected to criticism, and their defects pointed out. The system of some sort of a partnership between capitalists and laborers obviates many of these defects, but is not without its attendant difficulties. Mr. Larned has given cogent reasons for his preference, and we hope they will be given the consideration they deserve. His views are so opposed to everything that is visionary, and are kept in such a close relationship to the facts, that his critics will find him no mean antagonist.

We had marked for comment other points in this original and interesting book, which we have no space for. What has been said falls short of doing the author justice. Indeed, this book is so compacted, and so brimful of suggestive lines of inquiry, that no summary of it can be adequate. It is a calm presentation of a difficult subject, and the temper of its conclusions will give it weight in the solution of pending problems. It has a mission which it is bound to serve worthily. The task the author unpretentiously set himself has been well done, and to other merits must be added that of literary excellence. The matter is presented in the shape of a series of conversations, and they are conducted with a skill which provokes a sharp interest in the discussions from beginning to end. The argument is carried on logically; each proposition is separated and clearly put. Those who take up the book will lose little time in finishing it, and they will find in its pages much good and substantial thought.

CORRECTION.—It was erroneously stated last month in the review of the "Scientific Basis of Faith" that the book "is an attempt to harmonize Scripture with science." The reading should be "it is *not* an attempt," etc., conveying just the opposite meaning.

PUBLICATIONS RECEIVED.

The Theory of Color in its Relation to Art and Art-Industry. By W. von Bezold. Pp. 300. With Colored Plates. Boston: L. Prang & Co. Price, $5.

Fifty Years of my Life. By George Thomas, Earl of Albemarle. Pp. 430. New York: H. Holt & Co. Price, $2.50.

Ivanhoe. Pp. 287. Our Mutual Friend. Pp. 350. (Condensed Classics Series.) Same publisher. Price, $1.

Elementary Biology. By Prof. Huxley and H. N. Martin. Pp. 280. New York: Macmillan. Price, $2.

A Song of America. By V. Voldo. Pp. 206. New York: Hanscom & Co.

California Notes. By C. B. Turrill. Pp. 242. San Francisco: Bosqui & Co. print. Price, $1.50.

Theory and Calculation of Continuous Bridges. By M. Merriman. Pp. 130. New York: Van Nostrand. Price, 50 cents.

Goethe's ausgewählte Prosa. Edited by J. M. Hart. Pp. 200. New York: Putnams. Price, $1.

Die aromatischen Nitroverbindungen. Von Peter Townsend Austen. Pp. 43. Also, Ueber Dinitroparadibrombenzole und deren Derivate. Pp. 3. Same author.

Proceedings of the American Chemical Society. Vol. I., No. 1. Pp. 81. New York: J. F. Trow print.

Papers on Building Associations. Pp. 29. Philadelphia: Social Science Association.

Democracy: The First Century of the National Life. By Josiah Riley. Pp. 55. San Francisco: Carmany & Co. print.

Continuous Girders and Draw-Spans. By A. J. Du Bois, C. E. Pp. 32. Philadelphia: Kildare print.

Determination of Secondary Meridians by Electric Telegraph. Pp. 29. Washington: Hydrographic-Office.

Development and the Deity. By H. Faulds. Pp. 41. Yokohama: F. R. Wetmore & Co.

Bulletin of the Nuttall Ornithological Club. September. Cambridge (Mass.): published by the Club.

Report of the Director of the Central Park Menagerie. Pp. 57. New York: The National Printing Co.

The Greenstones of New Hampshire. By G. W. Hawes. Pp. 9. From *American Journal of Science and Arts.*

Conflict between Darwinism and Spiritualism. By J. M. Peebles. Pp. 34. Boston: Colby & Rich.

Researches in Telephony. By A. Graham Bell. Pp. 10. From "Proceedings of the American Academy of Arts and Sciences."

Seventh Catalogue of New Double Stars. By S. W. Burnham. Pp. 4. From *American Journal of Science and Arts.*

Prehistoric Remains found at Cincinnati. By Robert Clarke. Pp. 34. Cincinnati, 1876.

Nature of Diphtheritic Poison. By B. Robinson, M. D. Pp. 15. New York: W. Wood & Co.

Book of the Balance of Wisdom: An Essay. By H. C. Bolton, Ph. D. Pp. 30. New York: J. F. Trow print.

Proceedings of the Davenport Academy of Natural Sciences. Vol. I. Pp. 293. With numerous Plates.

MISCELLANY.

Supplement to the Glacial Theory.—At the Buffalo meeting of the American Association Prof. W. C. Kerr, State Geologist of North Carolina, read a paper accounting for the presence and characteristics of the drift or unstratified superficial deposits of North Carolina, which cannot be attributed to glacial action or the action of water, and which has hitherto presented a somewhat puzzling problem to geologists. He considers it to be the result of land-slides, or, as he terms them, earth-glaciers, formed from the detritus of the stratified rocks of the foot-hills mixed with water—the mass throughout its whole depth, of from fifteen

to thirty feet, being penetrated by the frosts of the glacial epoch, and subject to the same laws of action as real glaciers.

The course of the fragments of different strata, as shales, quartz-veins, etc., can be traced down the slopes, showing unmistakably the mode of action; and the distribution of bowlders and of gold throughout this drift, though otherwise inexplicable, is readily accounted for by this hypothesis.

A Note on the Radiometer, by Prof. T. C. Mendenhall, of Columbus, Ohio, explained his method of illuminating this instrument for the purpose of projecting an enlarged image of the arms or fans upon a screen.

The radiometer being suspended vertically, a beam of light is reflected upward through it, and made to fall upon a mirror above, which, with the aid of a projecting lens, produces the image of the movable fans upon the screen. As the beam of light produces no motion when striking these fans edgewise, the most delicate experiments can be made, and their effects seen, without any disturbance caused by the light used in projection.

On cooling the Air of Buildings during Hot Weather, by Prof. Simon Newcomb, was a valuable paper, which was practical enough to satisfy those who demand that the value of all scientific labors shall be tried by the test of utility. The failure of the many plans which have been suggested for cooling buildings in summer has arisen from overlooking the fact that the human body is a "wet-bulb thermometer," and that the air needs not alone to be cooled, but to be brought to a condition which will allow speedy evaporation, and that, therefore, contrivances for simply cooling the air have not resulted in a degree of comfort at all commensurate with their trouble and expense. We have but to remember the discomfort of a moist, "muggy" day, even when the mercury marks a moderately low temperature, to see that the air needs not only to be cooled, but to be dried. It will not answer to dry the air by chemical absorption, as by sulphuric acid or lime, on account of the heat of the chemical union.

The only satisfactory way to remove the moisture is by condensation and deposition, and for the purpose of doing this effectually and economically Prof. Newcomb suggests an apparatus. He proposes, by passing the ordinary air of a summer day through an ice-chest, to reduce it to a point far below the dew-point—or, say, 35° Fahr. Thence it should be passed through a very large tin tube on its way to the outside air. Inclosing this cold-air tube, is to be another, still larger, through which warm air from the apartments is to be forced; the two streams passing in opposite directions, the readily conducting substance of the tubes facilitating the vigorous efforts of the hot and cold currents to reach an equilibrium, the moisture being, meantime, rapidly deposited on the large condensing surfaces of the tubes. The outlets of the tubes are to be together, and the resulting mixture would be a volume of dry air at a comparatively low temperature. If, for example, the air in passing through the ice-box was reduced to 35°, while the air admitted to the outer tubes was at 95°, the result would be a mixture of dry air at about 70°, which, if mingled in considerable volume with the ordinary air of a room on a hot summer day, would be greatly conducive to comfort. The greatest value of Prof. Newcomb's suggestion is in utilizing the cold air on its passage for the purpose of condensing moisture. As to the quantity of ice needed to cool a given space, Prof. Newcomb was not prepared to give any exact figures, although he had made some estimates. He thought, however, that, at the price of ice in Washington, the cost of cooling the Capitol would be forty or fifty dollars per day.

Some New Points regarding the Tongue of the Picus Viridis (green woodpecker) was the title of a brief paper by Dr. Joshua Lindahl, of Sweden, in which he pointed out some errors in the common descriptions of the remarkable extension of the hyoid bones over the skull, which characterizes the woodpecker family. Having occasion to dissect the head of the green woodpecker of Sweden, he observed that the elongations of the posterior cornua of the hyoids, instead of passing symmetrical-

ly over the skull and terminating at the posterior end of the bill, as usually depicted in the text-books, were both carried to the right of the median line of the skull, and extended along the right side of the upper mandible, nearly or quite to its tip. Subsequent examination of numerous specimens showed this to be an accidental variation, but characteristic of the genus. A few of the black and pied species were examined, showing the same lack of symmetry, and differing only in the horns or muscles terminating at the base of the bill. Dr. Lindahl offered no explanation of these peculiarities, but called attention to the fact that the food of the green species varied considerably from that of the others, being sought deeper in the trees, and hoped that ornithologists and entomologists would consider the points of sufficient interest to seek their explanation. In the brief discussion which followed, the *asymmetry* of position and the *extension* of the muscles to the end of the mandible were spoken of as of interest, and as being new to ornithologists. While it is always important that errors in our text-books should be pointed out and corrected, the assumption that the facts are wholly new would seem to be somewhat hasty.

In this connection it may be sufficient to point out that Huxley ("Anatomy of Vertebrated Animals") says: "The free ends (of the posterior cornua) are inserted between the ascending and maxillary processes of the *right* pre-maxilla." In the "American Cyclopædia," the point of attachment is stated to be "usually near the opening of the *right* nostril;" while Wilson, writing early in the century, describes them as follows: "The os hyoides is divided into two branches that pass, one on each side of the neck, to the hind-head, where they unite, and run up along the skull in a groove; descend into the upper mandible by the *right* side of the right nostril, and reach to within half an inch of the point of the bill, to which they are attached by another extremely elastic membrane. In some species these cartilaginous substances reach only to the top of the cranium; in others they reach to the nostril; and in one species they are wound around the bone of the right eye, which projects considerably more than the left for their accommodation."

Bartlett's Ozone-Generator.—An apparatus for the generation of ozone was exhibited to the Association by the inventor, Dr. F. W. Bartlett, of Buffalo.

The machine is divided into three parts, each having a share in the process. The base, or generator, is a glass vessel eight inches high, with a projecting rim at either end; the interior space, four and a half inches in diameter, being divided into eight compartments by projections from the inner wall, extending one and a quarter inch toward the centre. This unoccupied centre has a movable cylinder which, when in position, completes the walls of the separate cavities. In each of these a tablet of phosphorus, one by two inches, and one-eighth of an inch thick, is suspended in water by a fusible wire—the fusible wire being used so that in cases of ignition, which sometimes occurs, the phosphorus may be completely submerged and the flame extinguished. Resting upon the base is a conical cylinder, eight inches high, and with a diameter at the top of five inches, composed of double walls of wire-cloth, between which lies some porous material saturated with a strong alkaline solution. This presents an effectual bar to the passage of phosphoric acids, while it permits the free transit of the ozone. Above this eliminating-chamber is a second glass cylinder about eight inches in height, with an aperture at the top through which passes a glass rod carrying a plunger for displacing the water in the base, and by means of which the tablets of phosphorus may be raised or lowered. The space thus provided above the phosphorus is about eighteen inches, and is considered by the inventor indispensable to the full utilization of the phosphoric vapor in the production of ozone.

In its present form the machine is employed chiefly for disinfecting purposes, and performs such work not only thoroughly but very cheaply. For ozonizing the atmosphere of a house, the slow oxidation of 100 to 150 grains of phosphorus daily will suffice. It is entirely manageable and without any disagreeable odor.

Dr. Bartlett claims that ozone possesses very important curative properties, has employed it successfully in numerous cases of asthma, hay-fever, typhoid fever, scarlatina, diphtheria, puerperal fever, erysipelas, etc. He predicts that its introduction will work great changes in the medical treatment of zymotic or malarial diseases. While making due allowance for the enthusiasm of an inventor, it must be admitted that Dr. Bartlett has produced a machine which does well the work for which it was intended.

Science in the United States.—Sir William Thomson, in the presidential address to the Physical Section of the British Association, spoke as follows of the work of some of our American scientific men:

"I wish I could speak to you of the veteran Henry, generous rival of Faraday in electromagnetic discovery; of Peirce, the founder of high mathematics in America; of Bache, and of the splendid heritage he has left to America and to the world in the United States Coast Survey; of the great school of astronomers which followed—Newton, Newcomb, Watson, Young, Alvan Clark, Rutherfurd, Draper, father and son; of Commander Belknap and his great exploration of the Pacific depths by piano-forte wire with imperfect apparatus supplied from Glasgow, out of which he forced a success in his own way; and of Captain Sigsbee, who followed with like fervor and resolution, and made further improvements in the apparatus by which he has done marvels of easy, quick, and sure deep-sea sounding in his little surveying-ship Blake; and of the admirable official spirit which makes such men and such doings possible in the United States naval service. I would like to tell you, too, of my reasons for confidently expecting that American hydrography will soon supply the data from tidal observations, long ago asked of our own Government in vain by a committee of the British Association, by which the amount of the earth's elastic yielding to the distorting influence of sun and moon will be measured; and of my strong hope that the Compass Department of the American Navy will repay the debt to France, England, and Germany, so appreciatively acknowledged in their reprint of the works of Poisson, Airy, Archibald Smith, Evans, and the Liverpool Compass Committee, by giving in return a fresh marine survey of terrestrial magnetism to supply the navigator with data for correcting his compass without sights of sun or stars. I should tell you also of 'Old Prob's' weather-warnings, which cost the nation $250,000 a year, money well spent, say the Western farmers, and not they alone; in this the whole people of the United States are agreed; and though Democrats or Republicans playing the 'economical ticket' may for half a session stop the appropriations for even the United States Coast Survey, no one would for a moment think of starving 'Old Prob;' and now that 80 per cent. of his probabilities have proved true, and General Myer has for a month back ceased to call his daily forecasts 'probabilities,' and has begun to call them 'indications,' what will the Western farmers call him this time next year?"

The French Association.—The fifth session of the French Association for the Advancement of Science was opened at Clermont-Ferrand, on the 18th of August. In the opening address, the president, M. J. Dumas, sketched the history of the British Association, pointing out the great services rendered by that body in popularizing science. Similar results are to be expected from the French Association. Of the place occupied by science in modern life, he said: "Natural science is no longer content with the contemplative attitude which sufficed for Newton and Laplace. Science is now mixed up with all the personal acts of our existence; she interferes in all measures of public interest; industry owes to her its immense prosperity; agriculture is regenerated under her fostering care; commerce is forced to take her discoveries into account; the art of war has been transformed by her; politics is bound to admit her into its councils for the government of states. How could it be otherwise? Have not mechanics, physics, chemistry, the natural sciences, become intelligent and necessary agents for the creation of wealth by labor? If comfort is more universal, the life of man more prolonged, wealth better distributed, houses more commodious, furniture and clothing cheaper, the soldier better armed, the finances of the state more prosperous, is it not to the sciences that all this progress is due? . . . Whether we wish it or not, we must needs accept Science as a companion, to possess her or to be possessed by her. If you are ignorant, you are her slave; if you are skilled, she obeys you. The future belongs to science; unhappy are they who shut their eyes to this truth."

Japanese Metallurgy.—A writer in the *Japan Mail* describes as follows the Japanese method of obtaining mercury from its sulphide (cinnabar): The cinnabar is first

powdered by means of an iron, boat-shaped mortar, with a circular knife. It is then washed to remove the foreign matter, and to obtain the cinnabar in a finely-powdered state. This is, after being dried, mixed with an equal weight of half-burned charcoal (half coal and half ashes), and the whole is put into an iron pot, which is carefully covered with a round iron cover. This cover has in the middle a round opening, into which a curved tube of iron is fixed and cemented with a mixture of loam, salt, and a little water, the other extremity of the tube ending in a pot filled with cold water. The whole tube is wrapped in some fibrous substance, and kept cool by aid of cold water. The whole is generally heated on a small open charcoal furnace, the quicksilver distilling into the pot of water. This process is founded on the fact that the sulphur of the cinnabar is retained by the ashes, and perhaps, also, by the iron of the inner surface of the pot, the mercury evaporating by the heat. This quicksilver is, however, not pure, but always contains a small quantity of foreign metals (lead, copper, etc.).

Action of Light on Selenium.—The action of light in modifying the electrical conducting power of selenium was first observed by May, a telegraph-operator at Valencia, Ireland, who communicated the facts to Willoughby Jones in 1873. The latter having fully confirmed the observations of May, the attention of physicists, both in England and Germany, was drawn to the subject. Within the last twelve months it has been made matter of special inquiry by Prof. Adams and by Dr. Werner Siemens, each carrying on his investigations independently of the other. The results obtained by Siemens are set forth in a lecture delivered at the London Royal Institution by his kinsman, C. W. Siemens. He exhibited the action of light by a contrivance of Dr. Werner Siemens, in which the selenium was in a form in which the surface-action of light can produce its maximum effect. Two spirals of thin wire (iron or platinum) are laid on a plate of mica in such a way that the wires lie parallel without touching. While in this position a drop of fluid selenium is made to fall upon the plate, filling the interstices between the wires; and, before the selenium has had time to harden, another thin plate of mica is pressed down upon it so as to give firmness to the whole. The two protruding ends of the spirals serve to insert this selenium element in a galvanic circuit. Mr. Siemens calls this disk his "sensitive element." The whole arrangement is no larger than a sixpence. Its action was shown in this way: It was placed in a galvanic circuit, at one end being a Daniell cell, and at the other a delicate index galvanometer. The "disk" was first inclosed in a dark box; the circuit was "made," but no electricity passed through—no movement of the index was seen. The "disk" was then exposed to light; still no action was apparent. Another disk was taken that had been kept in boiling water for an hour, and gradually cooled. In the dark box it gave a slight passage to electricity as indicated by the index, but as soon as the light was admitted the index registered a great passage of electricity. Another disk heated to 210° C., and allowed to cool, was then used, and a greater action still was apparent with this. Dr. Werner Siemens has worked at the meaning of this, but without tables and diagrams it is not possible to convey an adequate idea of his results. The basis of the change in condition seems to lie in the fact of the extent to which the selenium is heated, for, when again allowed to cool, its behavior depends on the extent to which it has been heated. The experiment was shown of the effect of different parts of the spectrum on a disk. The actinic ray produces no effect, but the influence increases as we approach the red end. A selenium photometer was also shown in action, the principle of which is to compare the relative effects of two lights in affecting the conditions for the passage of electricity. At the end of the lecture a most interesting little apparatus was put at work, which Mr. Siemens calls a selenium "eye." There is a small hollow ball, with two apertures opposite to each other. In one is placed a small lens, one and a half inch diameter, and at the other a "disk." The disk is connected with a Daniell cell and a galvanometer, and this represents the retina. There are two slides

which represent the eyelids. The action of light on the disk is indicated on the galvanometer. Not only was this shown to be sensitive to white light, but sensitive in different degrees to different colors. Mr. Siemens suggested it would not be difficult to arrange a contact and electro-magnet in connection with the galvanometer in such a manner that a powerful action of light would cause the automatic closing of the eyelids, and thus imitate the spontaneous brain-action of blinking the eyelids in consequence of a flash of light. To physiologists this analogy may be suggestive regarding the important natural functions of the human frame.

Effect of Alcohol on Brain-Substance.—When brain-substance is placed in alcohol, it loses its water and its mobility of particles, and becomes more solid and firm. The question here arises, Is this thing possible with the living brain? Is it possible that, in cases of delirium tremens, so much alcohol has been consumed as, by its diffusion through the brain, it has robbed nerve-matter of its mobile character, and consequently of its power to throw off the products of its life-functions? That alcohol may, in this way, act upon the brain of the inebriate, is an opinion which, as yet, can hardly be demonstrated directly; but an experiment made by Mr. Charles T. Kingzett seems to render it highly probable. He places in a dilute solution of alcohol pieces of brain-substance derived from the ox, at the temperature of the blood, viz., 100° Fahr. At this temperature it is digested for some hours, and the liquid is then filtered. On cooling, the filtrate throws down a white deposit of matter which the alcohol has dissolved—a phenomenon which would seem to indicate some actual truth in Shakespeare's words, "O that men should put an enemy in their mouths to steal away their brains!"

Foray of an Army of Ants.—A writer in *Land and Water* gives an interesting account of a foray by an army of ants, which he witnessed in South Africa. This army, estimated to number about 14,000 ants, started from their home in the mud walls of a hut, and marched out in the direction of a small mound of fresh earth in the vicinity. The head of the column halted on reaching the foot of the mound, and the remainder of the force did likewise till the entire army was assembled. Then the forces were divided: one part remained at the foot of the mound and ran round and round it; the rest mounted to the top, and some of them entered the loose earth and speedily returned, each bearing a young grasshopper or cricket, dead, which he deposited upon the ground and returned for a fresh load. Those who had remained on the outside of the mound took up the crickets as they were brought out of the earth, and bore them down to the base of the hill, returning for a fresh load. Soon the contents of the mound seemed to be exhausted, and then the whole force returned home, each carrying his burden of food for the community. Here was a regular foray, planned and executed with military precision, the country surveyed, and the depot of provisions known accurately before the march was made; at the mound, prudential division of labor, and care taken that none of the victims should escape.

Remedy for Cold in the Head.—Dr. David Ferrier, having used with great success trisnitrate of bismuth to cure "cold in the head," sends to the *Lancet* a communication in which he warmly commends the employment of bismuth, either alone or in conjunction with other drugs, in the treatment of nasal catarrh. Bismuth of itself being heavy, and difficult to inhale, it is advisable, he writes, to combine it with acacia-powder, which increases the bulk, and renders the powder more easily inhaled, while the secretion of the nostrils causes the formation of an adherent mucilaginous coating, of itself a great sedative of an irritated surface. The sedative effect is greatly strengthened by the addition of hydrochlorate of morphia, which speedily allays the feeling of irritation and aids in stopping the reflex secretion of tears. He proposes the following formula: Hydrochlorate of morphia, two grains; acacia-powder, two drachms; trisnitrate of bismuth, six drachms. Of this powder one-quarter or one-half may be taken as snuff in the course of twenty-four hours. The inhalations should be commenced as soon as the

symptoms of catarrh begin to show themselves, and should be used frequently at first, so as to keep the interior of the nostrils constantly well coated. The powder checks the flow of mucus, and stops the sneezing. It causes scarcely any perceptible sensation. A slight smarting may occur if the mucous membrane is much irritated and inflamed, but it rapidly disappears. After a few sniffs of the powder, a perceptible amelioration of the symptoms ensues, and in the course of a few hours, the powder being inhaled from time to time, all the symptoms may have disappeared.

Evolution of the Horse.—Prof. Huxley devotes the sixth and last lecture of a course upon the origin of existing vertebrate animals to considering the evidences of the evolution of the horse. After tracing the genealogy of the horse from Orohippus, through Palæotherium, Hipparion, etc., to Equus, the author remarks as follows: "The evidence is conclusive as far as the fact of evolution is concerned, for it is preposterous to assume that each member of this perfect series of forms has been specially created; and if it can be proved, as the facts certainly do prove, that a complicated animal like the horse may have arisen by gradual modification of a lower and less specialized form, there is surely no reason to think that other animals have arisen in a different way. This case, moreover, is not isolated. Every new investigation into the Tertiary mammalian fauna brings fresh evidence, tending to show how the rhinoceros, the pigs, the ruminants, have come about. Similar light is being thrown on the origin of the carnivora, and also, in a less degree, on that of all the other groups of animals. It is not, however, to be expected that there should be, as yet, an answer to every difficulty, for we are only just beginning the study of biological facts from the evolutionary point of view. Still, when we look back twenty years to the publication of the 'Origin of Species,' we are filled with astonishment at the progress of our knowledge, and especially at the immense strides it has made in the region of paleontological research. The accurate information obtained in this department of science has put the *fact* of evolution beyond a doubt; formerly the great reproach to the theory was, that no support was lent to it by the geological history of living things; now, whatever happens, the fact remains that the hypothesis is founded on the firm basis of paleontological evidence."

Wood Pavements.—After a very thorough investigation of the advantages possessed by different kinds of pavements—granite, asphalt, and wood—the corporation of London has decided in favor of the last. The report of the city engineer shows that a horse traveling on a granite pavement may be expected to fall once for every one hundred and thirty-two miles traveled, on asphalt once in one hundred and ninety-one miles, and on wood once in four hundred and forty-six miles. The injury sustained by the animal is also far less serious from a fall upon wood than upon asphalt or upon granite. The mode of constructing wooden pavements in London appears to differ from that which has obtained in this country. The surface-water is kept out by means of a layer of asphalt, and there is a flooring of planks as a superstructure, which gives great elasticity, and by distributing the weight equally over a considerable area, adds to the power of endurance of the pavement. This decision of the London Corporation will occasion surprise on this side of the water, where wooden pavements have been pronounced an utter failure. It remains to be seen whether good material and careful construction will avail to remove the capital objection to wood as a material for pavements—its liability to speedy decay.

The Ice Age in Great Britain.—In a paper on the Ice age in Great Britain, R. Richardson cites facts with regard to the shallow depth of the ocean between Great Britain and Iceland and Greenland on the one side, and over the German Ocean on the other, and adduces reasons for holding that in the glacial era this region was *terra firma;* that the glaciers of Great Britain came over this emerged land from the north and west; and that the cold of the glacial era was due, in part at least, to the closing thus of the Arctic and exclusion of the Gulf Stream. The facts appear to war-

rant these conclusions. We give them as stated briefly in the *American Journal of Science:*

"The depth between Britain and Iceland mostly does not exceed 100 fathoms, and nowhere exceeds 1,000; one tract of sea, extending in a straight line from the eastern coast of Greenland, *via* Iceland and Faroe, to Scotland, does not exceed 500 fathoms. The depth of the sea in the English Channel is only about 20 fathoms, and the average depth of the German Ocean is not over 40 fathoms. The depth between Britain and Greenland is small compared with the average depth of the Atlantic. According to the author, one of the oscillations of level, such as have occurred over the earth's surface, had the effect to unite Britain and Northern Europe with Greenland and the arctic regions, to give the polar ice-fields access to Europe, to divert the course of the Gulf Stream and free Northwestern Europe from its influence, and, in conjunction probably with some diminution in the influence of the sun, to produce a glacial epoch."

Pet Snakes.—Frank Buckland communicates to *Land and Water* a very interesting notice of "Cleo," a pet boa-constrictor. This animal was of the kind called "painted boa," and had come from Brazil. Its length was seven feet five inches, and its weight nine pounds. Cleo came into the possession of Mr. Mann, a friend of Mr. Buckland's, in 1870, and from that time till its death was his constant companion. Her food consisted of pigeons, of which she took on the average one a week. If a pigeon were offered to her when she was not hungry, she would take but little notice of it. If the two were left together for a while, they became friends. Neither pigeons nor any other animal ever showed any fear of this serpent.

She always "killed her bird" instantaneously, seizing it by the beak, and breaking its neck by a rapid movement. She *never* crushed her prey to death, but invariably waited to see that it was motionless before laying her coils upon it. The constricting power was reserved for *mastication*, and was very sufficient for that purpose.

"We have, in traveling," writes Mr. Mann, "carried her about with us, both in railway-carriages and hotels, unsuspected by others, and no amount of inconvenience or discomfort appeared to distress her so long as we were near. She thoroughly understood the joke of keeping concealed when strangers were present. It was only when we were alone, or with our own family, that she came forth of her own accord to join the conversation. She never avoided children, but would allow them to take liberties which she would never have borne from any other stranger. When offended in any way, she simply walked off to some inaccessible corner, and waited the departure of the offender.

"I do not remember any young child showing the slightest fear when Cleo came to make acquaintance.

"The manner of Cleo's death was so much in accordance with her character that few of her friends will be surprised at what I have to tell.

"During last autumn I was laid up with a very serious illness. At first Cleo appeared to enjoy my being at home all day long, but soon began to understand, principally from my wife's anxiety, that there was something the matter, and she refused food. One night she came to my bed to talk to me as usual, but I was too ill to take any notice of her (indeed, I could neither move nor speak). She tried in vain to make me respond to her caresses, and, after a while, returned to her own bed, refused not only food, but water, and died within a day or two. To any one that knew her it was visible that she was suffering grief, as a dog is sometimes known to do under similar circumstances."

The Northerly Winds of California.—In a paper on the northerly winds of the great central valley of California, Mr. J. H. C. Bonte attributes to the prevalence of these winds the peculiar dry and moderately exhilarating climate of that region. Further, he asserts that without the north winds, and with the consequent increase of moist heat, the vegetation now cultivated in the valley would be crowded out by dense tropical growths. It is reasonable to believe that the desiccating power of the north wind, by preventing and dissipating the noxious exhalations of animal matter, acts as a preventive of disease. The north winds, following the rainy season, by drying and baking the soil, dissolve and pulverize its particles, thus freeing its productive powers. Fineness of fibre and concentrated nutriment are imparted to all the vegetable growths of the valley by the north wind, and it is possible that the grapes and strawberries of California may receive their delicate flavor from the same source. Cereal grains are made solid and flinty by this influence, and thus enabled to resist the damaging effects of moisture. The comparative exemption of the valley of California from the ravages of the weevil doubtless arises from the desiccating

power of the north wind; and the same cause checks the growth of fungi. The economical value of the north wind is discernible in its power to preserve from rapid decay houses, barns, fences, etc., and the same influence must protect iron from destructive rusts.

Effects of Lightning on Different Species of Trees. — The effects of lightning on various species of trees have been made a subject of investigation by Daniel Colladon, who communicates to the Geneva Society of Natural History the results of his observations. He states that, when a poplar is struck, all the upper part of the tree remains perfectly sound and green. The height above the ground at which the injuries appear does not, in large poplars, exceed the third of the tree's height. These injuries commence immediately below the junction of the strong branches with the trunk. In general they do not reach quite to the ground. It is always the tallest poplar that is struck. In some cases the storm will pass over trees of other species, and will explode on poplars, though they be of less height. M. Colladon has never met with any traces of carbonization. The cases in which several poplars have been injured by a single discharge of lightning are rare. One such case is recorded by the author where three poplars were damaged by the same stroke. These trees stood in a straight line, and about twelve feet distant from each other.

How they teach Geology in Rome.—The eminent archæologist, G. Mortillet, gives an amusing account of a class-lecture on geology which he once attended in the Roman University of the Sapienza. "I succeeded," he writes, "not without difficulty, in getting leave to be present at a lecture on geology. I was introduced into a large hall; in the middle stood a small table, at which four persons were seated. On the one side sat the professor in an arm-chair, and on the other three students in common chairs. Near the professor's seat was a more comfortable arm-chair for the inspecting prelate, who from time to time came to see that the teaching went on aright. As a stranger supposed to be well-disposed, I was honored with a seat in the grand arm-chair. I expected to listen to an interesting lecture in good Italian; the more, inasmuch as the professor, Ponzi, now a Senator of Italy, is a distinguished man, and a *savant* of repute. But I was disappointed. The professor, for upward of half the time of the lesson, was obliged to dictate—for such was the rule—his lecture, which had been written in advance in Latin, and revised and corrected by the censor. During the latter half he was permitted to give in Italian explanations of the dictated paragraphs; but he was not at liberty to diverge from his text, nor could the students take notes. These things I have seen with my own eyes at Rome under the reign of Pius IX., author of the 'Syllabus.'"

Effects of Compressed Air on Animals.—The mechanical effects of compressed air upon the animal economy, as ascertained by Bert, are to cause a lowering of the diaphragm and liver, and a consequent increased pulmonary vital capacity; this effect, while gradual in its production, lasts long after the subject is withdrawn from the compressed-air bath. Pravaz finds that the heart's action is at first increased, and then lessened, the pulse first becoming more rapid, and then slower, but never falling below the rate at normal pressure. The respirations are diminished during immersion, but on removal of the increased pressure they rise in frequency and in direct proportion to the degree of compression. There is an increase in the amount of urea excreted, but this increase diminishes the longer the sojourn in the compressed air. There is at the same time an increase in the amount of carbonic acid expired. The temperature of the body rises above the normal at first, and then falls as the immersion is prolonged. These varying effects are due, Pravaz thinks, to the two influences of inward atmospheric pressure and hyper-oxygenation, the former tending to diminish the circulation and the organic changes, and the other to increase them.

Occurrence of Nickel-Ores.—Nickel-ores occur in great abundance in New Caledonia, and are being actively worked. These ores in no way resemble those from which nickel

has hitherto been extracted, being silicates of nickel and magnesia, while the others are arsenio-sulphurets. They are found in serpentine rocks, which are very abundant in various parts of the island, associated with diorites, amphibolites, etc. Sometimes they appear on the various rocks as a beautiful green coating; sometimes they penetrate the rocks, giving them a more or less intense color; sometimes they form therein threads, which may assume the importance and regularity of veins; and sometimes, again, they occur in pockets. As might have been expected, the nickel is associated with iron, chrome, and cobalt, these metals, especially the two former, being very abundant; their stratification is analogous to that of nickel, except where cobalt is met with. The latter metal is associated with manganese, forming pure masses, of greater or less extent, in the midst of friable arenaceous rocks, composed of feldspathic and magnesian detritus.

Age of Trees in Relation to Time of Leafing.—In the course of a discussion, in the Paris Académie des Sciences, of the question whether the annual buds of a tree, as it grows old, preserve the characters of youth or share in the old age of the individual which produces them, it was stated that, according to observations made by Prof. Decaisne on the *Robinia pseudacacia* (common locust) of the Muséum d'Histoire Naturelle, the time of leafing does not vary with age. At Pisa, results a little different were obtained; there the gingko (*Salisburia adiantifolia*) and the walnut have been found to produce their leaves earlier in the season from year to year as they have advanced in age. On the contrary, the *Æsculus hippocastanum*, or horse-chestnut, is more tardy in proportion as it grows older. M. de Candolle, who was present at the meeting of the Academy, quoted observations carefully made every year since 1808 on two chestnut-trees at Geneva; these trees have leaved invariably between the ninety-third and the ninety-sixth day of the year. He further quoted the instance of a vine growing at Ostend. This vine has been observed during thirty-three years, and during the first eleven years it leaved on the one hundred and twenty-seventh day of the year; in the second period of eleven years, on the one hundred and twentieth; in the third, on the one hundred and sixth. Thus there would seem to be a continuous progression, the vine becoming more precocious in proportion to its advance in age.

Effects of Electricity on Particles suspended in Liquids.—Some interesting observations by Holtz on the effects of electricity on particles suspended in liquids are recorded in *Poggendorff's Annalen*. In giving an account of these observations, Holtz remarks that the "migration" of particles suspended in a liquid, subjected to electric currents, has long been known, and was thoroughly investigated by Quincke. But in all cases of such motion Holtz finds that there is, at the same time, a clinging of particles to one of the poles. This is sometimes so evident that one might construct an electroscope on this principle for ascertaining the polarity. Especially notable is the tendency of *semen lycopodii* in insulating liquids, particularly sulphuric ether, to cover the negative pole with a thick coating; while sulphur, cinnabar, or sulphide of antimony, in the same liquid, only coats the positive pole. A simple medicine-glass suffices for the experiment, a conductor or half-conductor being introduced through the stopper. The glass is held in the hand, and the conductor brought to an electric machine; the phenomenon then occurs. It is better, of course, to have the bottom perforated for insertion of the second pole, or to use an open glass, with the two poles pushed down into it. Either a frictional or an influence machine may be used.

Have Bees a Sense of Hearing?—Though the best observers deny to bees the possession of a sense of hearing, a writer in *Newman's Entomologist* relates an instance in which a hive of bees appear to have heard the summons of their queen. A swarm of bees had been gathered into a hive, which was allowed temporarily to rest upon a table. On lifting the hive, in order to set it upon the hive-board, the portion of the table on which the hive had stood was found to be covered with bees, which soon began to run about, from their having been

suddenly disturbed. The hive was now placed on the hive-board, with the entrance toward the bees. For a little while they continued to run about, as if bewildered, but then was heard a peculiar vibrating and buzzing sound proceeding from the hive. In an instant all the bees faced about, with their heads toward the hive, and all marched into it in regular procession.

A New Respirator.—A new mask for filtering dust out of the atmosphere, and intended for use by workmen who follow sundry unhealthy trades, has been devised by Dr. B. W. Richardson. Having tried various substances in order to find a good filter, he gives the preference to feathers. The advantages of feathers as filters of dust are many: they are light, they separate perfectly, admitting air in any quantity while excluding dust, and they absorb water less perhaps than any other porous flexible substance. They have the further advantage of being cheap, and of being easily made up into filters. In constructing his mask he connects the light feathers drawn from the leg-plumage of the pheasant along a line of tape. This band he wraps around the perforated breathing-tube of the mask, so that the feathers fall over the perforations. In inspiration the feathers come down over the perforations, filtering the air as it enters, while in expiration they are blown out from the tube as feather-valves.

Bat-Guano.—In reply to a circular of inquiry addressed to numerous correspondents in the Southern States, Mr. McMurtrie, chemist to the United States Department of Agriculture, received a number of letters describing deposits of "bat-guano." Near Georgetown, Williamson County, Texas, there is a deposit supposed to amount to hundreds of tons, many apartments in the cave in which the excrement is found being filled to the mouth. Near Tuscumbia, Alabama, is a deposit estimated to be worth $20,000. A cave near San Antonio, Texas, is supposed to contain 15,000 or 20,000 tons of this guano, and the store is annually increasing. Samples from these and other deposits have been analyzed by Mr. McMurtrie. Most of them he found to contain both ammonia and nitrates. Under the microscope the material is seen to consist of the remains of the hard parts of insects in a finely-comminuted condition, which are the source of its nitrogenous constituents. As a fertilizer this guano compares favorably with the fish-products manufactured in New England, and even with Peruvian guano.

Prof. Marsh and his Paleontological Work.—Prof. O. C. Marsh, in a lecture to the graduating class of Yale College, summed up the main results of his paleontological researches in the Rocky Mountains. A syllabus of the lecture is published in the *American Journal of Science*. His conclusions as to the size and growth of the brain in mammals, from the beginning of the Tertiary to the present time, may be briefly stated thus: 1. All tertiary mammals had small brains. 2. There was a gradual increase in the size of the brain during this period. 3. This increase was mainly confined to the cerebral hemispheres. 4. In some groups the convolutions of the brain have gradually become more complicated. 5. In some the cerebellum and olfactory lobes have even diminished in size. There is some evidence that the same law of brain-growth holds good for birds and reptiles from the Cretaceous to the present time. Some additional conclusions in regard to American tertiary mammals as far as now known are as follows: 1. All the ungulata from the eocene and miocene had upper and lower incisors. 2. All eocene and miocene mammals had separate scaphoid and lunar bones. 3. All mammals from these formations had separate metapodial bones. At the conclusion of the lecture Prof. Marsh announced that his work in the field was essentially completed, and that all the fossil remains collected and in part described were now in the Yale College Museum. In future he should devote himself to their study and full description, and he hoped at no distant day to make public the complete results.

Seed-Production of the Sugar-Beet.—From experiments made by Corenwinder, it appears that when beet-roots are planted for the sake of seed, they, on first sprouting, part with a certain quantity of their

sugar, which goes to support the young leaves. From this time forward until the moment when the rudiments of the seeds appear, the sugar remains in the root. Hence it would appear that the carbon requisite for the formation of the stems and leaves, which during this period attain a great development, comes mostly, if not entirely, from the atmosphere. From the time when the seeds appear, the sugar in the root disappears rapidly, and when the seed is fully ripe there is no more left.

The Kauri Pine.—The kauri pine is one of the chief timber-trees of New Zealand. These trees in some instances have been found fifteen feet in diameter and one hundred and fifty feet in height. In some kauri trees the wood is prettily marked or mottled, and is in great demand for cabinet-making. The timber is also valuable for ship-building. The kauri does not grow farther south than latitude 37° 30′. The gum which exudes from this tree is an article of commerce. Over a large area of land which has been exhausted by kauri forests in past ages, and is now barren, the gum which has exuded from the dead trees is found at a depth of from two to three feet. This gum is valuable in the manufacture of varnish. During the years 1870, 1871, and 1872, no less than 14,276 tons of the gum were exported, amounting in value to nearly half a million pounds sterling. The Maoris bring a considerable quantity to market, and the proceeds thus obtained enable them to procure the comforts of dress and living to which they have now become accustomed.

An Important Sanitary Fact.—The following interesting statement is made by Dr. Littlejohn, Medical Officer of Health for Edinburgh: "Edinburgh consists of two distinct towns, an old and a new, but with very different populations. The new town is inhabited by the better classes, and is preëminently a water-closet town; whereas the old town consists for the most part of overcrowded tenements, in which pails are used for the reception of excreta. These pails are brought to the street daily and emptied into carts provided by the authorities. Considering the low morality of the population, the bad ventilation, the overcrowding, and the retention of the filth in the living-rooms for the greater part of the day, it might naturally have been supposed that typhoid and diphtheria would be endemic in the old town. This is not the case, however, for, despite the surrounding conditions, these diseases may be said to be practically unknown. But in the new and water-closeted town the case is quite different: typhoid and diphtheria are never entirely absent, are frequently epidemic, and it has been noticed that the ravages of these diseases have been greatest in the best houses. The lesson which this teaches is, that any system of removal cannot be sanitary unless all the excremental produce of a population is so promptly and so thoroughly removed that the inhabited place, in its air and soil, shall be absolutely without fecal impurities."

Utilization of Sewage in England.—Down to the year 1874 the sewage of the English town of Coventry (population 40,000) was cast into the river Sherbourne in an undefecated state. It rendered the stream black and disgusting, and a terrible nuisance to the neighborhood, as well as a great source of danger to health, inasmuch as the sewage, at a few miles distance, found its way into the source of the water-supply of the town of Warwick. But, by the erection of sewage-works, all this has since been remedied, and the river Sherbourne has been so purified that fishes have returned to its waters. In selecting a site for the works, advantage was taken of a fall of six feet in the nature of the ground, so as to avoid the costly expedient of pumping the sewage, and to work it throughout by gravitation. A narrow strip of comparatively valueless land along the river-bank, about thirteen acres in extent, was thoroughly drained and embanked against the rising of the river during floods. The sewage is here subjected to four processes, viz.: 1. Straining by means of mechanical strainers, thus removing the solids, which form a rich manure. 2. Chemical treatment by sulphate of alumina and milk of lime, and precipitation. 3. Filtering of the effluent water by percolation through a depth of five feet of earth. 4. Drying of the precipitate or sludge in the precipitating tanks. The cost of purifying

the entire sewage of Coventry in this way, including rent of land and interest on capital, and without deducting receipts from the sale of manure, is about 1*s.* 7*d.* per head of the population per year. But, taking into account the chemical value of the manure, the cost would be about twopence per head.

Construction of Water-Tanks.—A water-tank at the top of St. George's Hospital, in London, recently burst, inundating the wards and causing destruction of life and property. This tank, which held about thirty-four tons of water, was made of cast-iron plates half an inch thick, bolted together in the usual way; in form it was a square of ten feet on a side and the depth twelve feet. The thickness of the iron plates was adequate to resist the strain put upon them only on the usual condition of the employment of tie-bars and nuts of the needed strength. But, instead of adopting the proper plan of bolting these tie-bars directly to the flanges by which the plates themselves were bolted together, thin plates of wrought-iron, only one-quarter of an inch thick, were bolted to these flanges, and the tie-bars were attached to cross-pieces that ran through holes in these plates. The cross-pieces were so short that on the least disturbance one end might slip out of its place, leaving the entire stress on the other end and on the thin plates in which it rested. As was to be expected, the plates gradually rusted, and, when the corrosion had advanced so far as to allow the bolt to be torn away by that strain on the sides of the tank which the cross-bars were intended to resist, the tank tore in two, and the water made its escape.

Movements of "Cold Waves."—Prof. Loomis, of Yale College, contributes to the *American Journal of Science and Arts*, for July, the fifth of his valuable series of papers on "Meteorology."

In a former paper he presented facts showing the origin and probable cause of extremely low temperatures. It was found that they developed among the Rocky Mountains, and moved thence, as "cold waves," over the continent eastward. Since the publication of that paper this phenomenon has become well understood, and is now sustained by further proof. It appears that low temperatures follow in the wake of storms; or, in other words, areas of high barometer follow those of low barometer.

By low temperature is understood a degree of cold which is greatly below the mean temperature of the place or area where it prevails. Thus the cold wave of December, 1872, started in Dakota on the 16th, and the temperature fell to 15°, 25°, and finally 44°, below the mean of the month. At the same time the barometer rose to 30.64.

The cold wave moved eastward and southeastward, the barometer rising as the cold came on. The cold was extreme from the Rocky Mountains to Lake Michigan, and from latitude 38° to the British possessions.

In New York, during the last six days of the month, the depression of temperature ranged from 18° to 24° below the mean of the month.

It is quite obvious, Prof. Loomis observes, that the cold experienced in Dakota did not come from beyond the Rocky Mountains, but on the easterly side, near longitude 100°. The greatest observed cold in the instance referred to was not at the most northern stations, which strengthens the conclusion expressed in a former paper that there is a source of cold independent of the transfer of air from a higher to lower latitudes. As the cold wave moves eastward, the intensity of the cold is found to diminish.

The professor calls attention to the very interesting fact that, during the low temperature of December, 1872, the stratum of cold air was of no great thickness, probably not more than 9,000 feet, as was shown at Mount Washington. On the 26th of the month, when the cold was at its maximum over the region, it was found that the temperature was higher by 20° Fahr. at the summit of the mountain than at its base.

Further facts are presented in this paper, showing the general form of areas of low barometer and of high barometer. It was previously shown that a storm area is more or less oblong, and not in any observed case entirely circular. The same appears to be true of the cold areas.

To illustrate this a chart is given, on which lines of equal barometric pressure are drawn, the lines of highest pressure being at and near the centre of the area, but diminishing as the distance from the centre is increased. These areas have a long and a short diameter, the one being in some cases twice or thrice that of the other.

The relation of barometric pressure to rainfall receives further attention in the present paper, and the conclusions previously arrived at are fully sustained.

The rainfall is greatest while the barometric pressure at the centre of the storm is diminishing, or the storm increases in intensity while the barometer continues to fall; and, on the other hand, the storm diminishes in intensity while the barometer at the centre of the storm is rising.

The progressive movement of storms seems to be sometimes interrupted, and they remain stationary over a section of country for some days. This occurs off the coast of Newfoundland, and the cause of it is attributed to unusual precipitation of vapor. In that region the rainfall is about fifty-six inches in a year, while at two hundred miles from the coast it is only forty inches.

Preservation of Entomological Specimens.—M. Felix Plateau having recommended the use of yellow glass in the windows of rooms containing entomological collections, as a means of preserving intact the natural colors of the specimens, M. Capronnier, of the Entomological Society of Belgium, made some experiments to determine the value of this suggestion. He made five small, square boxes, each covered with a pane of yellow, violet, green, blue, or colorless glass. He then fixed in the middle of each box one of the inferior wings of *Euchelia Jacobeæ*, which are of a deep carmine color, uniform in tone. Each wing was partly covered with a band of black paper, and their position was so arranged as to leave exposed successively each of the parts during a period of fifteen, thirty, and ninety days. The result was as follows: *Colorless Glass.*—The carmine tint visibly attacked after exposure of fifteen days; alteration more sensible after thirty days; after ninety days the carmine had passed into a yellowish tint. *Blue.*—The same results as with colorless glass. *Green.*—A change indicated on the thirtieth day; on the ninetieth the alteration was marked. *Yellow.*—After ninety days the carmine color almost intact. M. Capronnier accordingly concludes that a yellowish color should be preferred in every arrangement of an entomological room.

Anti-Vivisection Legislation.—In commenting upon the bill for regulating the practice of vivisection in England, *Iron* remarks upon the absurdity of a Parliament of sportsmen, supported by a mob out-of-doors, passing such a law. "Either of them" (sportsmen or mob) "for the mere pleasure of killing, or in the treatment of domestic animals, inflicts more unnecessary pain on the animal creation in one day than the whole body of physiological inquirers do in a year. The physiological worker will, if this bill passes, have to pursue his unrequited labors under the supervision of a policeman, and with a ticket-of-leave; and the result will be that original, unremunerated research of a most important class will not only continue to be pursued without endowment, but under the risk of penal servitude, the tournament of doves, pheasant-battues, and horse-racing, being all the while in full swing." A petition, signed by all the leading members of the medical profession, has been presented to the House of Lords, demanding certain modifications in the bill.

Meats cooked by Cold.—It is a fact of familiar experience that extreme cold produces in organic substances effects closely resembling those of heat. Thus, contact with frozen mercury gives the same sensation as contact with fire; and meat that has been exposed to a very low temperature assumes a condition like that produced by heat. This action of intense cold has been turned to account for economical uses by Dr. Sawiczevosky, an Hungarian chemist, as we learn from *La Nature*. He subjects flesh-meats to a temperature of *minus* 33° Fahr., and having thus "cooked them by cold," seals them hermetically in tin cans. The results are represented as being entirely satisfactory. The meat, when taken out of the cans a long time afterward, is found to be, as regards its appearance and its

odor, in all respects as inviting as at first. It is partially cooked, and needs but little treatment more to prepare it for the table. A German government commission has made experiments with this process, and two naval vessels dispatched on a voyage of circumnavigation were provisioned with this kind of meat. An establishment has been set up in Hungary for preserving meats in this way.

Causes of Putrefaction and Fermentation.—A year or two ago, Dr. J. Dougall, of Glasgow, at the Social Science Congress, held in that city, announced, as the result of investigations made by himself, that the presence of an alkali determines putrefaction in organic matter, while the presence of an acid determines fermentative changes. The same line of inquiry has been taken up since by Dr. John Day, of Victoria, Australia, who finds in Dougall's discovery an explanation of the presence in hospitals of septic poisons, giving rise to pyæmia, erysipelas, and puerperal fever. The *Sanitary Journal*, of Toronto, has a paper by Dr. Day upon this subject, the purport of which may be briefly stated as follows:

Hospitals, as usually constructed, have alkaline ceilings, alkaline walls, alkaline floors (owing to the use of soap in cleansing them). Experience has shown that pyæmia is of extremely infrequent occurrence in temporary hospitals consisting of rough wooden sheds. The incessant generation of peroxide of hydrogen by the turpentine of the wood doubtless prevents putrefactive changes, but, as turpentine always gives an acid reaction, this circumstance must greatly increase the disinfecting power of the peroxide, by determining the fermentative instead of the putrefactive decomposition of the pus-cells and other organic matter given off from the patient.

Dr. Day proposes the following method of counteracting the evils of hospital-life: The boards of the floor he would first cover with a coat consisting of equal parts of gasoline and boiled linseed-oil, to which is added a little benzoic acid. When dry, the surface is polished with a paste of beeswax, turpentine, and benzoic acid. Boards so prepared are, in his opinion, rendered permanently disinfectant. The walls and ceilings might be rubbed smooth, and coated with a varnish of paraffine or oil of turpentine; or, better still, they might be coated with silicate paint, then rubbed down and varnished. For the purpose of keeping the air pure, and destroying the pus-cells floating in it, he recommends, in addition to ventilation, the use of certain volatile substances, such as gasoline, benzine, and eucalyptus oil. The furniture should be occasionally brushed over with either gasoline or benzine, in which a little benzoic acid has been dissolved.

Cultivation of Caoutchouc-yielding Trees.—In 1870 Mr. Clements R. Markham advocated the planting of caoutchouc-yielding trees in India, and in 1873 the first attempts were made, but without success, in the Darjiling Terai and in the district of Goalpara, Assam. In the following year two plantations were made in the Kamrup district of Assam and at Charduar, at the foot of the Himalayas, in the Durrung district. The latter plantation now covers 180 acres, and in 1875 there were in it 16,401 live cuttings. The species here cultivated is the native *Ficus elastica*. Several plants of the *castilloa* tree of South America are now in a very flourishing condition at Kew Gardens, and a good supply of this species has been thence forwarded to India, where they will form the nucleus of extensive plantations. In June of the present year an agent was to have been sent out to Brazil to collect healthy young plants of the *hevea*, the tree which yields the famous Pará India-rubber. Thus provision will be effectually made against the extinction of these valuable species of plants.

Inspecting Railways by Machinery.—Attached to the rear of the paymaster's car on the Pennsylvania Railroad, says the *American Manufacturer*, is an apparatus which it is thought will work much more satisfactorily than the telegraphic instruments formerly used by the officers while making their tours of inspection. A roll of white paper, 700 feet in length, encircles a cylinder, from which it is paid out at the rate of three feet to the mile run by the car, its forward movement being regulated

by the revolutions of the nearest axle under the car. A lead-pencil placed about the centre of the paper indicates by its mark the condition of the track. The more uneven the track the longer will be the mark made by the pencil. Another way of showing the inspecting party that the track is uneven is by an horizontal piece of iron or steel, which oscillates like the pendulum of a clock as the train moves. When a very defective point is reached, the pendulum comes in contact with a metal on each side, circular in shape, which gives a sound like a bell.

Physiological Action of Coca.—The physiological action of the leaves of coca or cuca (*Erythroxylon coca*), a plant indigenous to Peru, has been the subject of much discussion lately in England. Sir Robert Christison, whose reference to the peculiar properties of this plant, in his address to the Edinburgh Botanical Society last November, gave rise to the discussion, has since taken up the subject again, in a paper read before the same society. The author gives an account of experiments made by himself and by fourteen other observers, under his instructions, with a view to determine the physiological action of coca and its principle, cocaine. His conclusions are that—1. When taken in quantities of two drachms by healthy persons it has no unpleasant, injurious, or suspicious effect whatever; 2. In a very few cases this dose of an inferior sample had no effect at all; 3. In by far the greater number of instances, and with a fine sample, extreme fatigue was removed and prevented from returning; 4. It does not in the end impair the appetite or digestion, although hunger, even after long fasting, is taken away for an hour or two; 5. The use of it is incompatible with the use of alcoholic liquors, except when the latter are taken in very small quantities.

NOTES.

In a recent Miscellany article on the cruise of the Challenger, it was stated that 4,975 fathoms, or five and a half miles, is the deepest trustworthy sounding yet made, excepting two by the Tuscarora, which showed a depth 600 feet greater. A correspondent has called our attention to a statement in No. IV. of the "Science Primer Series," to the effect that between the Azores and Bermudas a sounding had been obtained of seven and a half miles. This sounding was made twenty years ago, by Lieutenant Berryman. It was in latitude 32° 55′ north, and longitude 47° 58′ west, but it is not now regarded as trustworthy. A fruitful source of error, in this and other early soundings, was the curving of the line by currents, etc.

S. W. Burnham, Esq., of Chicago, has been appointed director of the Dearborn Observatory in that city. Mr. Burnham's contributions to observational astronomy, mostly published in the "Transactions" of the Royal Astronomical Society of London, have earned for him prominent rank among astronomers, both at home and abroad.

In a recent Italian work, measurements are given of the skulls of Dante, Petrarch, Ugo Foscolo, and Volta. Volta's skull is of extraordinary capacity. In the skull of Petrarch the Etruscan type is evident, viz., a voluminous brain, strongly developed in all its parts, and of superior psychological power; but the posterior predominates over the anterior portion, leading to the conclusion that the sentiments and instincts prevailed over the intellect.

It is asserted, by Prof. Isidor Walz, that vanadium is a general constituent of American magnetites. This conclusion is based upon examination of twenty-seven specimens of magnetites from different localities, in the United States and Canada.

In Austria, according to the *Moniteur Industriel Belge*, dynamité has been employed with success in vine-culture. In order to loosen the soil and permit access of air and moisture to the vines, cartridges of dynamite were placed in holes three metres deep, at such distances from the plants as to obviate the danger of injury to them from an explosion. The result of the explosion was that the soil was perfectly broken up to the depth of two and a half metres. Furthermore, the phylloxera completely disappeared. Certainly a novel use for explosive agents.

Died June 27th, at the age of eighty-two, Christian Gottlieb Ehrenberg, the eminent microscopist. In 1820 he was attached to a scientific expedition into Egypt, and for six years devoted himself to the microscopic investigation of the lower animal forms of that and the neighboring countries. On his return home he was appointed a professor in the medical faculty of the Berlin University. In 1829 he accompanied Humboldt to Central Asia. He was the author of numerous works upon microscopic organisms.

A COMPANY has been formed in California for the manufacture of sugar from the juice of watermelons. The process is far simpler and cheaper than that of making sugar from beets. An excellent sirup is also made from watermelon-juice. The seeds yield a sweet-oil which serves as a good substitute for olive-oil, and the residue of the sugar-manufacture is used as food for cattle.

THE death is announced of Dr. Lonsdale, the pupil and biographer of Dr. KNOX, the celebrated Edinburgh lecturer on anatomy. Dr. Lonsdale was also the author of some pleasant volumes on "Cumberland Worthies."

A NEW geological map of Scotland, by Prof. Geikie, is announced in *Nature*. The scale is ten miles to the inch. In addition to the older rocks, this map shows the position of the more important raised beaches, river alluvia, tracts of blown sand, and glacier moraines.

ON June 6th and 7th a cremation congress met at Dresden. The attendance was not large. Nearly all the German governments are opposed to cremation of the dead, chiefly, as it would appear, because many of the leading advocates of this substitute for interment are pronounced radicals. The Saxon Government has refused to accept, for the benefit of the Dresden charitable institutions, the legacy of Prof. Eberhard Richter, simply because the testator had coupled with the bequest the condition that his body should be burned in a furnace at Dresden.

IT is stated by Prof. de Luca, of Naples, that fruits or leaves kept in an atmosphere of carbonic acid, or of pure hydrogen, after a while begin to ferment. In the carbonic-acid atmosphere, alcohol and acetic acid are produced, and in the hydrogen mannite. In neither case do any organic ferments appear. If this observation should prove to be correct, it will lead to important consequences.

LIQUID mercury has been discovered in the ground near Montpellier, and at many points in the department of Hérault, France. It is especially found in decomposing schists, but its appearance seems to be intermittent. Its presence is marked by injurious effects on the vegetation: the trees languish and die, the pasturage is spoiled, and the sheep grazing on such ground present the symptoms of mercurial poisoning.

WIRE ropes of phosphor bronze are much employed in the hoisting-apparatus of mines in Europe. Such wire ropes are much stronger and more durable than those of iron or steel.

SILKWORMS hatched by electricity are now being reared in Italy. The superintendent of the experimental silkworm-farm at Padua has found that the hatching of silkworms may be accelerated ten or twelve days, and a yield of forty per cent. of caterpillars secured, by exposing the eggs to a current of negative electricity from a Holtz machine for eight or ten minutes. It is suggested to apply the same method to hens'-eggs and to hastening the germination of seeds.

PROF. TAIT calls attention to a paper by F. Mohr, published in Liebig's *Annalen*, as early as 1837, which contains views on the nature of heat similar to those published later by Dr. Mayer. Mohr's essay is said to contain about all that is correct in Mayer, while avoiding some of his errors.

THERE are in Algeria 613 artesian wells, representing a total depth of over 26 kilometres (16.12 miles). The cost of these wells, including one of exceptional depth (596 metres, or about 2,000 feet), was 2,500,000 francs, or 95 francs per metre.

A LIVING gorilla has been brought to Europe from Africa, by the remnant of the Güssfeldt expedition. The animal is in good condition, and is to be placed in the Zoölogical Gardens at Berlin. He is two years old.

THE Society of Medicine and Surgery, of Bordeaux, offers a prize of 1,000 francs for the best essay upon the following subject, viz.: microscopical examination of human blood, both in the flesh and in the dry state, of the fœtus and of the adult, as compared with the blood of other mammals, from the medico-legal point of view. The essays offered must be written in either Latin or French, and submitted to the secretary of the society not later than August 31, 1879.

THE "Cochin-China diarrhœa" annually carries off about 1,000 men of the French army and navy. According to Dr. Normand, naval surgeon, this disease is produced by the presence in the intestines of an enormous number of entozoöns, of the new species *Anguillula stercoralis*. This entozoön is one-fourth of a millimetre in length.

GEORGE SMITH, of the British Museum, famous for his Assyrian researches, died at Aleppo, August 19th, at the early age of thirty-seven years.

THE *Cologne Gazette* says that Frau Theresa Fiedler von Hülsenstein, who lately died at Prague, had attained the age of one hundred and nineteen years. She was born at Hamburg in 1757, and was in her youth a maid-of-honor to the Empress Maria Theresa.

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Alfred Marshall Mayer